American Journal of Transplantation 2008; 8: 58–68
Blackwell Munksgaard

doi: 10.1111/j.1600-6143.2007.02020.x

The Overlapping Risk Profile Between Dialysis Patients Listed and Not Listed for Renal Transplantation

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The survival advantage of kidney transplantation extends to many high-risk ESRD patients; however, numerous factors ultimately determine which patients are evaluated and listed for the procedure. Broad goals of patient evaluation comprise identifying patients who will benefit from transplantation and excluding patients who might be placed at risk. There is limited data detailing whether current access limitations and screening strategies have achieved the goalof listing the most appropriate patients. The study estimated the life expectancy of adult patients in the United States prior to transplantation with ESRD onset from 1995 to 2003. Factors associated with transplant listing were examined based on patient prognosis after ESRD. Approximately one-third of patients listed for transplantation within 1 year of ESRD had $\leq$5-year life expectancy on dialysis. In contrast, one-third of patients not listed had $>$5-year life expectancy. The number of patients not listed with 'good' prognosis was significantly higher than those listed with 'poor' prognosis (134 382 vs. 16 807, respectively). Age, race, gender, insurance coverage and body mass index (BMI) were associated with likelihood for listing with 'poor' prognosis and not listing with 'good' prognosis. Over the past decade, many ESRD patients viable for transplantation have not listed for transplantation while higher-risk patients have listed rapidly.

Key words: Access to transplantation, African–Americans, age, allocation, body mass index, dialysis, end-stage renal disease, insurance, kidney, transplantation, transplantation policy, waiting list

Received 1 August 2007, revised 31 August 2007 and accepted for publication 10 September 2007

Introduction

The well-documented survival advantage of kidney transplantation relative to the alternative treatment modality of maintenance dialysis pertains to many high-risk ESRD patients (1–5). Therefore, increasing access to transplantation for all patients who meet criteria for the procedure is an important goal for the healthcare community. Furthermore, as incremental dialysis exposure conveys an increasing risk for pre- and posttransplant mortality, timely access to kidney transplantation is of particular importance (6–8). There are multiple potential impediments for ESRD patients to be listed to receive a deceased donor transplant. These include timely referral from primary caregivers, economic and insurance issues, facility practices and appropriate patient education concerning the risks and benefits about the procedure (9–14). Delayed access to transplantation has been demonstrated to be more predominant in certain portions of the ESRD population including African–Americans, patients with lower socioeconomic status, patients in certain geographic regions, females and obese patients (15–23).

One of the greatest challenges facing the field of transplantation is the significant and growing disparity between the demand for transplantation and the supply of donor organs (24). Although efforts to increase donations have demonstrated impressive successes, the number of new wait listed patients continues to outweigh the increased supply of organs (25,26). One manner by which to reduce this disparity includes more selective initial criteria for candidate listing in order to reduce the number of patients with marginal potential gain from the procedure and correspondingly limit the growth of the transplant candidate population and accelerated waiting periods to receive a transplant. The predominant limitation to this strategy is in accurately identifying patients with minimal potential gain from the procedure as epidemiological studies have had little success identifying broad groups of patients who do not benefit from transplantation and many patients who were previously considered high-risk are now routinely transplanted (27).

Central to these issues is a need to understand and quantify (a) to what extent patients have been listed for transplantation with a relatively poor prognosis (and therefore may be unlikely to benefit from the procedure) and conversely (b) to what extent patients who have a relatively good

prognosis are not placed on the transplant waiting list. Our study was designed in order to provide insight into these two fundamental questions. We examined the new onset adult ESRD population in the United States from 1995 to 2003 with the purpose of depicting the risk profile of the wait list and maintenance dialysis populations and determine to what degree there exists an overlap of life expectancy between these groups. The study also examined factors associated with patient listing for a deceased donor transplant following ESRD onset and specifically the likelihood of listing with a poor prognosis or not listing with a good prognosis. Finally, we examined each of these questions on a temporal basis to assess whether listing practices have significantly changed over the past decade.

Methods

Study population

The study included adult patients aged 18–70 years with initial ESRD onset between 1995 and 2003. Patient data at the time of ESRD onset was derived from the CMS 2728 form associated with initiation of dialysis. Employment status was classified into four groups: employed (either full- or part-time), unemployed (including students or homemakers), retired and medical leave of absence. Primary insurance coverage was categorized hierarchically with any indication of employer group health insurance as the initial category, patients with no employer group health insurance and Medicare, and patients with neither employer group health insurance nor Medicare and with Medicaid. Indications of ischemic heart disease and myocardial infarction were found to be relatively collinear and as such were combined as patients who experience either condition versus those who did not have either indication.

Survival models

Several parametric forms for the survival model were tested for the primary outcome of death after ESRD onset including the Weibull, exponential, lognormal and gamma distributions. The Weibull distribution was selected for the final model based on a marginally larger value of the log likelihood statistic. In addition, visual inspection of the complementary log{–log[S(t)]} survival plot was conducted to confirm the appropriateness of the Weibull model. The model was specified as the time to death, censored at the earliest of transplant acquisition or last follow-up date. Patients who received a living transplant within the first year after ESRD were excluded from this model as listing patterns were considered less relevant to the analysis. The model was additionally utilized to estimate predicted survival following ESRD onset. For the purpose of classifying patients as having a 'good' or 'bad' prognosis on dialysis, a cutoff of a 5-year life expectancy was selected. As the survival model was censored at the time of transplantation, life expectancy was only indicative of patient prognosis while remaining on dialysis. Kaplan–Meier models were also generated for patient survival following 1 year of ESRD. These models excluded patients who died or received a transplant within the first year following ESRD and strata were defined based on whether patients were listed within the first year of ESRD. In addition, patients were categorized based on their survival expectancy using quartiles within each group.

Listing for transplantation

The study displays the proportion of patients with good and poor prognoses (as indicated by an estimated 5-year survival) out of all patients either listed or not listed for transplantation within 1 year of ESRD. In addition, Kaplan–Meier models were utilized to estimate the cumulative incidence of listing after ESRD censored at patient death, transplant acquisition or last follow-up date. Kaplan–Meier models were also utilized to estimate the proportion of patients receiving a transplant within 3 years following ESRD onset. These models were additionally censored at the time of transplantation for the alternative donor source (i.e. the proportion of deceased donor transplants were censored at the time of living donor transplantation). A logistic model was also generated for patients with at least 1 year of follow-up after ESRD onset to determine factors associated with not listing for transplantation. The c-statistic is displayed as a measure of the predictive power of the model.

All analyses were conducted utilizing SAS (v.9.3, Cary, NC).

Results

Demographics

The study population consisted of 465 711 patients aged 18–70 with ESRD onset between 1995 and 2003. Among these 11 504 patients received a living transplant within 1 year of ESRD and were not utilized for the initial survival model due to the likelihood that these patients' listing practices are directly related to having a living donor. Table 1 displays the characteristics of the study population categorized by patients who were listed for a deceased donor transplant within the first year. Eleven percent (n = 49 422) of patients were listed in the first year of ESRD. Listed patients were generally younger, more likely to be Caucasian and male, more likely to have diabetes as a contributing cause of ESRD, less likely to have comorbidities and be morbidly obese, and more likely to have private insurance and be employed.

Survival after ESRD

Results of the parametric survival model utilized to estimate patient life expectancy are displayed in Table 2. Younger age and non-Caucasian race were associated with increased life expectancy as indicated by the positive estimates in the model. Diabetes as a primary or contributing cause of ESRD, low albumin, tobacco use and presence of additional comorbidities were associated with decreased life expectancy. Other factors associated with increased life expectancy included patients who were currently employed and patients who had employer group health insurance. Reduced life expectancy was associated with lower body mass index (BMI); however, morbid obesity ($\geq$35 kg/m^2) was not protective relative to patients with a BMI in the 30–34 kg/m^2 range.

Figure 1 displays the distribution of life expectancy for patients from the time of ESRD onset stratified by patients listed for transplantation within 1 year. As depicted, there was a significantly longer life expectancy on dialysis for patients listed for transplantation; the median estimated survival of listed patients was 6.6 years as compared to 3.8 years in the nonwait listed population. Utilizing a cutoff of 5 years of life expectancy, 33% of ESRD patients (n = 134 382) had a 'good' prognosis but were not listed

Table 1: Demographic characteristics of the study population

Variable	Level	Listed within 1 year (%)	Not listed within 1 year (%)
Age	18–39	28	13
	40–49	26	17
	50–59	28	29
	60–69	18	41
Race	Asian	6	3
	African–American	29	36
	Caucasian	62	57
	Other	3	4
Gender	Male	60	54
	Female	40	46
Cause of ESRD	Diabetes (primary or contributing)	68	53
	Other	32	47
Congestive heart failure	No	87	71
	Yes	13	29
Cerebrovascular disease	No	97	92
	Yes	3	8
Albumin[1]	0–3 mg/dL	34	40
	> 3 mg/dL	66	60
Cardiac arrest	No	99	99
	Yes	1	1
Employment[1]	Employed (part- or full-time)	34	13
	Unemployed (including students and homemakers)	30	35
	Retired (age or disability)	28	48
	Medical leave of absence	8	4
Insurance[2]	Employer group health insurance	62	34
	Medicare	20	42
	Medicaid	18	24
Ischemic heart disease or myocardial infarction	No	90	78
	Yes	10	22
Inability to ambulate	No	99	96
	Yes	1	4
Pericarditis	No	99	99
	Yes	1	1
Chronic obstructive pulmonary disease	No	98	94
	Yes	2	6
Pulmonary vascular disease	No	95	87
	Yes	5	13
Smoking	No	95	93
	Yes	5	7
BMI[1]	13–19 kg/m^2	10	12
	20–24 kg/m^2	32	30
	25–29 kg/m^2	31	27
	30–34 kg/m^2	17	16
	35 + kg/m^2	10	14
Total		N = 49 422	N = 404 007

[1]Missing levels not displayed, proportions based on known levels.
[2]Insurance categorized hierarchically such that patients with Medicare were only classified as such if they did not have any Employer Group Insurance and patients classified with Medicaid if they did not have any indication of employer group insurance or Medicare.

for transplantation within 1 year. In contrast, 34% of patients (n = 16 807) who were listed for transplantation had a 'poor' prognosis (i.e. less than 5-year expected survival). By extending the period of listing to 2 years, the proportion of patients listed with 'poor' prognosis increased to 37% of patients, in contrast, the proportion of patients not listed with a 'good' prognosis decreased to 31%. These proportions using a 3-year threshold were similar, 38% of patients listed with poor prognosis and 31% were not listed with a good prognosis.

Figure 2 displays the proportion of patients with greater than 5-year life expectancy among patients who were not listed within 1 year of ESRD. Overall, this proportion (33%) changed little over the study period. However, these proportions were highly variable among different segments

Table 2: Multivariate model for survival on dialysis following ESRD onset

Parameter (reference)	Level	Estimate[1]	95% Confidence limits	Pr > chi-square
Age (60+)	18–39	0.77	0.76, 0.79	<0.001
	40–49	0.42	0.41, 0.44	<0.001
	50–59	0.22	0.21, 0.23	<0.001
Race (Caucasian)	Asian	0.48	0.45, 0.51	<0.001
	African–American	0.20	0.19, 0.21	<0.001
	Other	0.15	0.13, 0.17	<0.001
Gender (Male)	Female	<0.01	−0.01, 0.01	0.92
Primary cause of ESRD (Nondiabetes)	Diabetes	−0.09	−0.10, −0.08	<0.001
Albumin level (3+ mg/dL)	0–3 mg/dL	−0.31	−0.31, −0.30	<0.001
	Missing	−0.14	−0.15, −0.13	<0.001
Prior cardiac arrest (No)	Yes	−0.23	−0.19, −0.23	<0.001
Congestive heart failure (No)	Yes	−0.21	−0.20, −0.22	<0.001
Cerebrovascular disease (No)	Yes	−0.15	−0.13, −0.16	<0.001
Ischemic heart disease or myocardial infarction (No)	Yes	−0.15	−0.13, −0.16	<0.001
Inability to ambulate (No)	Yes	−0.45	−0.43, −0.47	<0.001
Pericarditis (No)	Yes	−0.01	−0.06, 0.03	0.57
COPD (No)	Yes	−0.21	−0.19, −0.22	<0.001
Peripheral vascular disease (No)	Yes	−0.15	−0.13, −0.16	<0.001
Tobacco use (No)	Yes	−0.10	−0.08, −0.11	<0.001
Employment status (medical leave)	Missing	−0.26	−0.29, −0.23	<0.001
	Employed	0.18	0.15, 0.21	<0.001
	Unemployed	−0.22	−0.25, −0.20	<0.001
	Retired	−0.30	−0.33, −0.28	<0.001
Insurance status (Medicaid)	Other/missing	0.16	0.15, 0.17	<0.001
	Private	0.13	0.11, 0.14	<0.001
	Medicare	−0.05	−0.07, −0.04	<0.001
Body mass index (35+)	Missing	−0.17	−0.19, −0.16	<0.001
	13–19	−0.34	−0.36, −0.33	<0.001
	20–24	−0.16	−0.17, −0.15	<0.001
	25–29	−0.03	−0.04, −0.01	<0.001
	30–34	0.02	0.00, 0.03	0.05

[1]Positive values indicative of longer life expectancy from ESRD, model censored at minimum of transplantation, death or last follow-up time.

of the population. Among younger patients (aged 18–49 years), 82% of African–Americans and 62% of Caucasians had greater than 5-year life expectancy that were not listed for transplantation. Among older ESRD patients (aged 50–69 years), 22% of African–Americans and 9% of Caucasians who were not listed within 1 year had a good prognosis. This proportion of patients also varied significantly among other subgroups including younger diabetics (85%), younger nondiabetics (60%), younger obese (82%) and younger nonobese (75%).

Figure 3 displays the proportion of patients who had a relatively poor prognosis (≤5-year life expectancy) among those who were listed for transplantation within 1 year. The overall proportion of patients across the study period was 34%, this proportion increased from 32% in 1995 to 38% in 2003. The proportion of older patients (aged 50–69 years) listed with a poor prognosis was higher among Caucasian patients (67%) as compared to African–American patients (48%). For younger patients (aged 18–49), this proportion was 16% for Caucasian patients and 5% for African–American patients. In addition, the proportion of both young (5% in 1995 to 9% in 2003) and old (51% in 1995 to 58% in 2003) obese patients with poor prognoses who were not listed significantly increased over the time period (data not displayed).

Kaplan–Meier survival plots for patients with at least 1 year of survival remaining on dialysis are displayed in Figure 4. The plots are stratified by patients wait listed within 1 year and further by survival expectancy calculated at the time of ESRD onset. Of particular note, the proportion of patients surviving in the lowest quartile of wait-listed patients (n = 10 766) was significantly less than the top quartile of patients not listed for transplantation within 1 year (n = 78 856). Wait-listed patients in the third quartile had equivalent 10-year survival as the top quartile of nonlisted patients and wait-listed patients in the fourth quartile had similar 10-year survival as the second quartile of nonlisted patients.

Likelihood of wait listing

The proportion of patients with less than 5-year life expectancy who were listed for a deceased donor transplant over time after ESRD onset is displayed in Table 3. Overall, 7% of these patients were listed within a year and 17% at 3 years. Rates of listing were significantly higher among

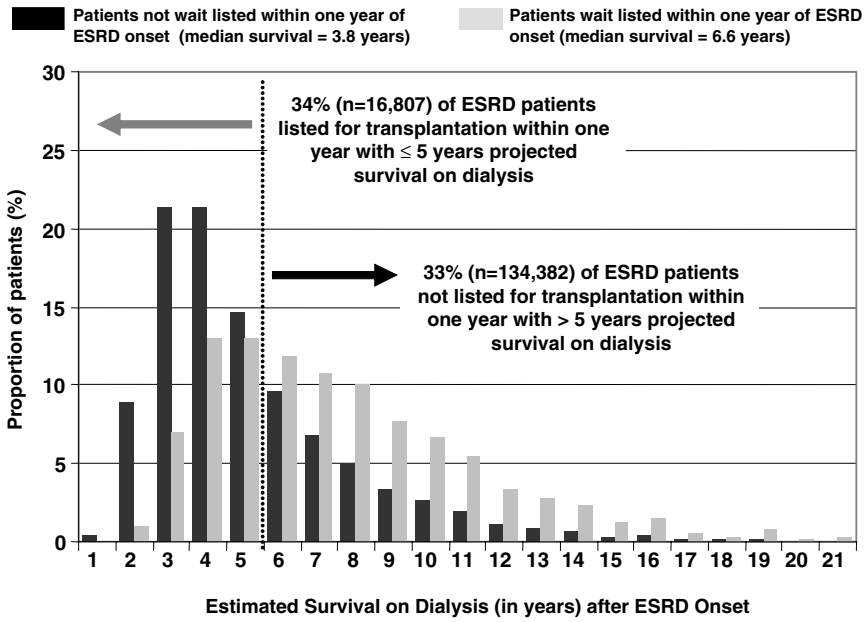

Figure 1: Projected survival following ESRD onset (excludes patients receiving a living transplant within one year after ESRD onset).

both younger and older Caucasian patients as compared to African–American patients. The proportion of listings at 3 years was higher among older males (18%) than older females (13%) and significantly higher for younger and older patients with private insurance relative to patients with public insurance at the time of ESRD. The proportion of these patients with 3-year survival who received living and deceased donor transplants was 2% and 5%, respectively.

Among patients with greater than 5-year life expectancy from ESRD onset, 23% of patients who survived and were not previously transplanted were listed for a deceased donor transplant within 1 year and 41% listed within 3 years (Table 4). Ten percent of these patients with 3-year survival received a living donor transplant and 12% received a deceased donor transplant. The proportion of these patients who listed for a deceased donor transplant significantly varied by race, gender, diabetes as a cause of ESRD, BMI and type of insurance. The proportion of patients receiving transplant also was highest among Caucasians, males, nonobese patients and patients with private insurance.

Factors associated with patients' not listing for transplantation at 1 year after ESRD are displayed on Table 5. There was a progressively increased likelihood for older patients not to be listed relative to the youngest patients. African–American patients were less likely to be listed relative to Caucasians. Female patients were significantly less likely to list relative to males. Patients with low albumin and both low and high BMI were less likely to be listed. Patients employed and with private insurance at the time of ESRD onset were significantly more likely to be listed. Multiple comorbidities and history of tobacco use were also associated with decreased likelihood for listing.

Discussion

The primary finding of our study indicates that there is a significant overlap in the risk profile of patients that are listed as transplant candidates and those who are not listed following ESRD onset. This is of particular interest as one of the often-cited strategies to potentially ameliorate the disparity in available donor organs and transplant candidates is to impose more selective guidelines for listing patients for kidney transplantation (28–30). Proponents of this approach hypothesize that increased selectivity of the listing process will not only reduce the demand for transplantation by excluding high-risk candidates, but also increase the longevity of grafts by reducing the number of patient deaths with functioning grafts and in turn decrease new listings for repeat transplantation. However, our study suggests that while restricting transplant listing to only patients with a given life expectancy would exclude a significant proportion of patients who are currently listed, a much larger number of viable patients not listed would be eligible to be placed on the waiting list.

Based on our results depicted in Figure 4, there is evidence to suggest that many patients on the kidney transplant waiting list (categorized into the lowest quartile of survival expectancy) perhaps should be excluded from the waiting list as their survival would likely be limited even after kidney transplantation. Over the study period, this group included almost 11 000 patients. Alternatively, it is also apparent from this figure that among dialysis patients not listed for transplantation, the top quartile of patients has reasonable survival expectancy and many of these nearly 80 000 patients should be listed utilizing life expectancy as the main driving factor for allocation. Therefore, the cumulative impact of listing all patients with

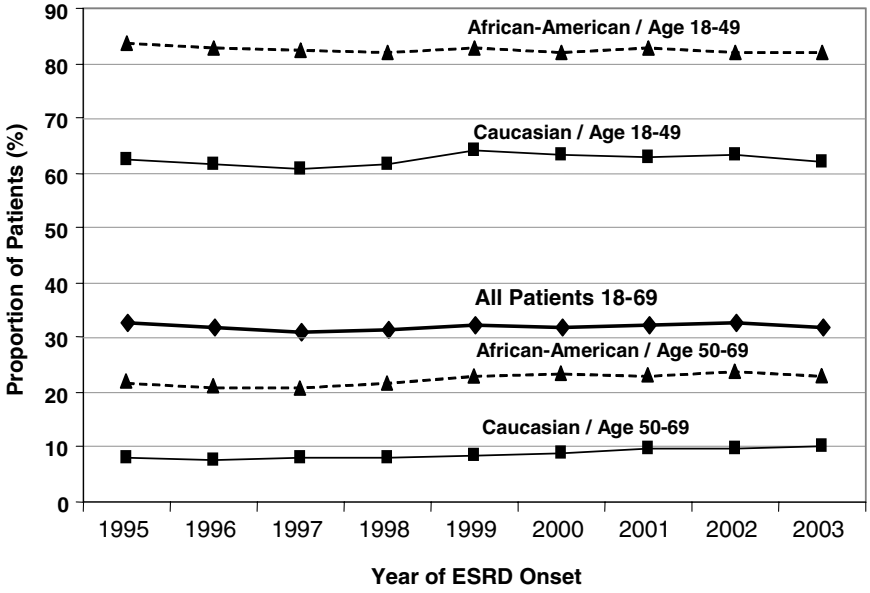

Figure 2: Proportion of patients with *greater than* 5-year life expectancy among patients not listed for transplantation within 1 year (proportion based on patients with at least 1 year survival and were not transplanted within the first year of ESRD onset).

'adequate' life expectancy for transplantation would substantially increase, rather than decrease, the kidney transplant waiting list from the current level of approximately 70 000 to almost 140 000 patients accompanied by successful efforts to increase access to viable patients. In other words, our study suggests that in relative terms, the problem of not listing patients rapidly for transplantation is paramount and significantly outweighs concerns of more selectively screening candidates who are listed with diminished potential benefit from the procedure.

Of course, there are important caveats to the findings of this analysis and the estimated impact of different listing strategies. First of all, among patients with good life expectancy who are currently not listed for a transplant, there exists a certain subset of patients who simply do not prefer transplantation as a therapeutic option independent of medical need (12,31). However, it is also likely that the majority of patients with a good prognosis who are not listed are encountering well-described access problems rather than a lack of interest. In fact, the patient groups identified in this study who are not listed despite having a good prognosis are disproportionately represented groups that have been described to have access barriers to kidney transplantation such as African–Americans, females and patients with less generous insurance coverage (10,16,19). Additional sources of disparities in delayed time or failure to list for transplantation have been attributed to a lack of education, financial issues, late referrals and workups from providers, differences in belief systems and also a perception among physicians as to the viability of certain patients' potential prognosis after the procedure (16,20,31,32). These phenomena may also have significant regional components and in many cases,

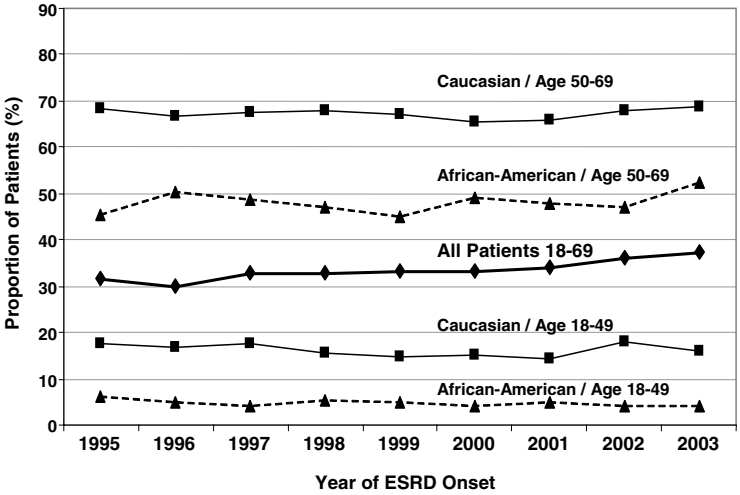

Figure 3: Proportion of patients with *less than* 5-year life expectancy among all patients listed for transplation within 1 year (proportion based on patients with at least 1 year survival and were not transplanted within the first year of ESRD onset).

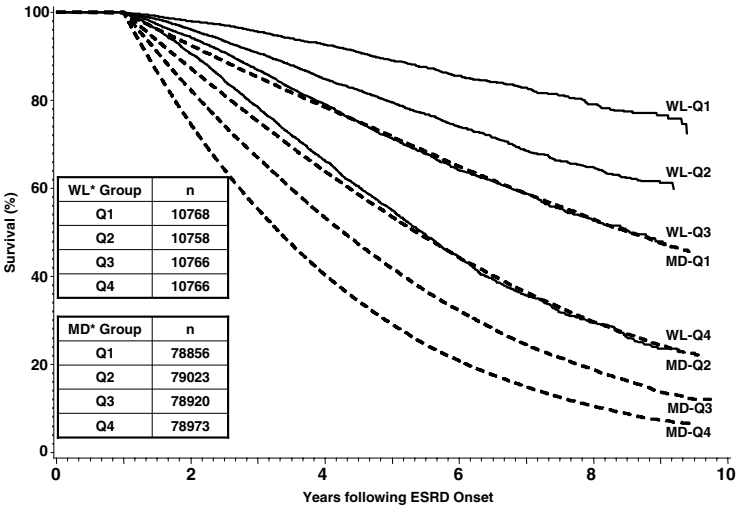

Figure 4: Kaplan–Meier plot of patient survival on dialysis from 1 year post ESRD onset. *WL = wait listed patients within 1 year of ESRD onset; MD = patients remaining on maintenance dialysis without listing for transplantation. Quartiles based on survival expectancy from ESRD onset derived from patient risk factors. Model displayed only for patients with 1 year of survival without receiving a transplant within the first year.

'appropriate' transplant candidates may be relative to the applicable dialysis population for a given center. A portion of the disparities may also reflect that while certain groups (e.g. African–Americans) have relatively equivalent patient survival rates following transplantation, graft survival rates may be significantly diminished, as such listing practices may incorporate these assessments of 'viability' that were not examined in our analysis. However, the magnitude of the overlapping risk profile of these populations suggests that enhanced procedures and policies governing access to transplantation are still required and improved understanding of the etiology of these disparities is needed.

Table 3: Proportion of patients listed and transplanted with less than 5-year life expectancy

	Proportion of patients listed for deceased donor transplantation by time after ESRD onset[2]			Living transplantation at 3 years following ESRD onset[3]	Deceased donor transplantation at 3 years following ESRD onset[3]
ESRD population[1]	1 Year (%)	2 Years (%)	3 Years (%)		
Younger/Caucasian	14	23	28	6	10
Younger/African–American	5	11	14	1	3
Older/Caucasian	8	14	17	3	6
Older/African–American	4	9	11	1	2
Younger/male	11	19	24	4	8
Younger/female	11	19	23	5	7
Older/male	8	14	18	2	5
Older/female	6	10	13	2	4
Younger/diabetic	11	20	24	5	8
Younger/nondiabetic	11	19	24	4	7
Older/diabetic	8	14	17	3	6
Older/nondiabetic	6	11	14	2	3
Younger/nonobese	8	14	17	5	8
Younger/obese	9	17	20	3	4
Older/nonobese	7	13	16	2	5
Older/obese	6	12	14	2	3
Younger/private insurance	18	28	35	8	12
Younger/public insurance	10	17	21	3	6
Older/private insurance	11	19	23	4	7
Older/public insurance	5	10	12	1	3
Overall	7	13	17	2	5

[1] 'Younger' defined as 18–49 years of age at ESRD onset, 'obese' defined as 30 kg/m^2 or greater, 'diabetic' defined as diabetes as a primary or contributing cause of ESRD, and 'public insurance' includes Medicare and Medicaid without indication of employer group insurance.
[2] Proportion based on Kaplan–Meier models censored at date of death, last follow-up period or transplantation.
[3] Proportion based on Kaplan–Meier models censored at death or last follow-up period.

A clear representation of differences in listing patterns among are reflected in Figures 2 and 3 in which the vast majority of young (particularly African–American) patients have good prognoses that are not listed, while in contrast there are very few young patients listed that have a poor prognoses. This suggests that there is minimal 'inappropriate' listing in the younger populations, while the majority of patients listed with diminished prognoses derive from older candidates. The ethnic disparities have remained substantial over the study period as well; in fact, our study indicates that for patients with either poor and good prognoses, even older Caucasians have higher rates of listing than younger African–Americans (9,33,34). The association between obesity and diminished access to transplantation has been previously reported despite research indicating a significant survival advantage of obese patients who undergo the procedure (3,4,15,35,36). Our study supported these findings, particularly among patients with good prognoses, although an additional finding was that the proportion of obese patients who have listed despite a poor prognosis has increased over the study period. Research has also identified female gender as a barrier to progressing through steps to attain a transplant (16,19). Interestingly, this study also detected a significant association of listing with gender, but after distinguishing gender by older and younger aged patients, the effect was most apparent in older females relative to older males. A striking difference in listing patterns also existed between patients with public versus private insurance. At one year, approximately twice the proportion of patients was listed for transplantation with private insurance as compared to public insurance even within the same age group and prognosis. Although a portion of this effect may be attributed to health status and the ability of patients to remain employed, the magnitude of the differences support the notion that socioeconomic status, patient education and logistical issues remain strongly associated with access to the transplant waiting list (16,37). The limited access to transplantation in patients with other comorbidities and diabetes has also been established, and to some degree this may be indicative of other health related issues not captured in the database. However, particularly in diabetic patients the survival advantage of transplantation is especially applicable and is reflected in practice by more rapid listing in this group (38–40).

In order to study our hypotheses, we stipulated several relatively artificial conditions. For instance, results were

Table 4: Proportion of patients listed and transplanted with greater than 5-year life expectancy

	Proportion of patients listed for deceased donor transplantation by time after ESRD onset[2]			Living transplantation at 3 years following ESRD onset[3]	Deceased donor transplantation at 3 years following ESRD onset[3]
ESRD population[1]	1 Year (%)	2 Years (%)	3 Years (%)		
Younger/Caucasian	31	45	51	19	20
Younger/African–American	17	28	34	5	7
Older/Caucasian	27	40	46	12	17
Older/African–American	13	24	30	3	6
Younger/male	25	37	43	12	14
Younger/female	23	36	41	11	12
Older/male	22	34	41	8	12
Older/female	17	28	33	6	9
Younger/diabetic	26	39	45	13	13
Younger/nondiabetic	19	30	36	8	13
Older/diabetic	21	34	39	8	12
Older/nondiabetic	17	28	34	5	8
Younger/nonobese	27	40	46	13	14
Younger/obese	22	34	40	9	10
Older/nonobese	22	34	40	8	12
Older/obese	17	28	34	6	8
Younger/private insurance	34	48	54	18	19
Younger/public insurance	17	28	33	6	9
Older/private insurance	25	38	44	9	14
Older/public insurance	11	21	25	3	6
Overall	23	35	41	10	12

[1]'Younger' defined as 18–49 years of age at ESRD onset, 'obese' defined as 30 kg/m2 or greater, 'diabetic' defined as diabetes as a primary or contributing cause of ESRD, and 'public insurance' includes Medicare and Medicaid without indication of employer group insurance.

[2]Proportion based on Kaplan–Meier models censored at date of death, last follow-up period or transplantation.

[3]Proportion based on Kaplan–Meier models censored at date of death, transplantation from alternative donor source or last follow-up period.

Table 5: Likelihood of not listing for transplantation within one year after ESRD onset[2]

Effect (reference group)	Level	Adjusted Odds Ratio	95% C.I.
Age (18–39)	40–49	1.42	1.37–1.46
	50–59	1.87	1.82–1.93
	60–69	3.37	3.26–3.49
Race (Caucasian)	Asian	0.67	0.64–0.70
	African–American	1.66	1.62–1.70
	Other	1.46	1.37–1.46
Gender (male)	Female	1.11	1.09–1.14
Cause of ESRD (other than diabetes)	Diabetes	0.76	0.74–0.78
Albumin level (>3 mg/dL)[1]	0–3 mg/dL	1.57	1.53–1.61
History of cardiac arrest (No)	Yes	1.48	1.23–1.78
History of congestive heart failure (No)	Yes	1.44	1.40–1.49
History of cerebrovascular disease (No)	Yes	1.46	1.38–1.54
Employment status (medical leave)[1]	Employed	0.82	0.79–0.86
	Unemployed	1.46	1.40–1.52
	Retired	1.33	1.27–1.39
Primary insurance (Medicare)[1]	Employer Group Health	0.57	0.55–0.59
	Medicaid	1.01	0.97–1.05
Ischemic heart disease or myocardial infarction (No)	Yes	1.23	1.19–1.27
Inability to ambulate (No)	Yes	3.27	2.85–3.75
History of pericarditis (No)	Yes	0.88	0.79–0.98
History of COPD (No)	Yes	1.62	1.51–1.75
History of peripheral vascular disease (No)	Yes	1.34	1.28–1.40
Tobacco use (No)	Yes	1.41	1.35–1.48
Body mass index (20–24)[1]	13–19	1.19	1.14–1.23
	25–29	0.91	0.88–0.93
	30–34	0.91	0.88–0.94
	35+	1.32	1.27–1.37

[1]Missing levels not shown.
[2]Includes patients who did not receive a transplant or die within the first year after ESRD onset, model c-statistic = 0.74.

depicted based on whether a patient was listed for transplant at one year. Certainly, this time period is somewhat arbitrary; however, based on other results, similar patterns existed when allowing longer time frames for listing from time of ESRD. Similarly, a 5-year expected survival is certainly not a clear distinction of good prognosis for patients; rather patient prognoses are characterized by a continuous risk profile. For the purposes of this analysis, this threshold was chosen as a representation of a time which patients could reasonably expect to receive a transplant and potentially accrue benefit from the procedure. In fact, our analyses also indicated only slight variations in the relative proportion of patients categorized into prognosis level by altering the time threshold for listing. This may suggest that rather than just differences in the time to listing among certain groups, the more predominant effects express a failure to be listed at all. Given the distribution of the continuous risk profile of patients listed and not listed for transplant, an alternative threshold of a good prognosis would certainly alter the number of patients in each group; however, the differences in listing patterns does not appear to be related to the specific value. Accordingly, the interpretations of the study results should not highlight the particular values used (i.e. patients should be listed with only a minimum 5-year life expectancy), but rather a significant overlap in life expectancy does exist between listed and nonlisted ESRD patients regardless of the specific criteria.

Interestingly, the proportion of ESRD patients that are not listed despite a good prognosis has been relatively stable over the past decade, while the proportion of patients listed with relatively poor prognosis has mildly increased over this time period. This indicates that over time, despite continued efforts and attention to place only viable candidates on the waiting list, more high-risk candidates have been listed while listing patterns for patients with long life expectancies on dialysis, for whom access barriers have been identified, have not substantially changed in the past decade. The increase in high-risk patient listing might not only be an expression of a changing selection process, but also a result of the aging ESRD population including higher-risk elderly patients in more recent years. In general, it may be inferred that from a population perspective selection criteria have become somewhat more liberal rather than more stringent (41).

Factors associated with survival on dialysis for candidates of transplantation have been examined in numerous studies (42–44). We present the factors that were utilized in our models for life expectancy (as seen in Table 2). Certainly

there are many additional factors associated with survival that are not known or collected on these forms as well as dynamic events that are not captured at the time of ESRD. Most of the risk factors for mortality depicted in this study are well known; however, one difference from certain past reports in our study was the absence of a protective effect of morbid obesity relative to obesity at lower levels (45). That is, rather than a monotonic risk acceleration associated with lower BMI, after adjustment for other comorbidities, patients with morbid obesity have equivalent mortality risk as patients with BMI in the 30–34 kg/m^2 range.

In conclusion, our study illustrates there is a substantial overlap of the risk profile of patients who are maintained on dialysis therapy and patients who list for transplantation. This overlap includes roughly one-third of patients who are listed for transplantation with less than a 5-year life expectancy and one-third of patients who are not listed for transplantation with a >5-year life expectancy. More appropriate selection of transplant candidates is certainly a desired goal but listing patients based strictly on prognoses would increase rather than decrease the organ shortage. Both patient and referring physician education will be critical toward improving the listing practices and the organ allocation process in the years to come.

Acknowledgment

The data reported here have been supplied by the United States Renal Data System (USRDS). The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as an official policy or interpretation of the US government.

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