Risk assessment score in pre-kidney transplantation: methodology and the socioeconomic characteristics importance

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Abstract

Introduction: Kidney transplantation is performed in emergency conditions in a population with high perioperative risk. Instruments for risk assessment before transplantation in this population are scarce. **Objective:** To develop a score with pretransplant variables to estimate the probability of success of kidney transplantation, defined as survival of the recipient and the graft with creatinine ≤ 1.5 mg/dl at 6 months. **Methods:** Analysis of variables of patients from a unique kidney transplantation center in São Paulo. Logistic regression was used to construct an equation with variables able to estimate the probability of success. Integer points were assigned to variables for score construction. **Results:** Of the 305 patients analyzed, 176 (57.7%) achieved success. Of the 23 variables identified by univariate analysis, 21 were included in the logistic regression model and 10 that remained independently associated with success, were used in the score. Four of these 10 variables were socioeconomic. It was great (area under the ROC curve 0.817) the power of discrimination between groups success and not success and adequate (Hosmer and Lemeshow = 0.672) the agreement between frequencies of the probabilities estimated by equation and frequencies of probabilities actual observed. There were correlation (0.982) between the estimated probability via the scoring system and the estimated probabilities via logistic regression. **Conclusion:** Point score simplified risk stratification of transplant candidate according to their probability of success. Socioeconomic variables influence the success, demonstrating the need for creation of prognostic tools utilizing clinical and demographic variables of our population.

Keywords: kidney transplantation; measures of association; exposure; risk; outcome; odds ratio; risk factors.

Introduction

Kidney transplantation is the treatment of choice for most patients on dialysis.[1] However, literature reports have described an overall surgical mortality rate of 1% to 4% for patients with chronic kidney disease (CKD). This rate is even higher in elderly and diabetic patients and may be five times higher in emergency settings.[2,3]

Deceased donor kidney transplants are carried out in emergency conditions. The candidate with the best HLA compatibility is known hours before the start of surgery. Additionally, the risk of preoperative morbidity and mortality in this population is high, given that besides CKD, they are often afflicted by other morbidities. The summation of perioperative risk and the risks associated with immunosuppressive therapy have resulted in a risk of death nearly three times higher when compared to patients kept on dialysis for the first two weeks after transplantation.[1]

Scoring systems and scales have been widely applied in different medical fields to estimate the probability of an outcome in quantitative terms.[4-8] In renal transplantation, several mathematical models have been published with the purpose of predicting survival and renal function following transplantation. However, the cumbersomeness often present in these models, the need to perform complex calculations, and the lack of information at the time of patient assessment have hindered a more widespread use of these tools in transplant centers. van Walraven *et al.*[9] published a scale to estimate the five-year risk of death of patients on dialysis for renal transplantation. The author used a statistical methodology similar to ours to assign integer scores to the relative risks of 12 demographic variables associated with outcome. However, such a system requires the use of accurate data on patient total time on a waiting list, time until listed for transplant, serum albumin, and eight comorbidities, which may hamper the application of the scale. Scales were also designed to quantify the risk of graft loss based on different donor characteristics.[10] Nyberg *et al.*[11] proposed a scale to identify renal grafts from deceased donors associated with high risk of early renal dysfunction. However, the arbitrary stratification of risk categories may have contributed to this scale's reduced accuracy.

Various cohort studies have identified pre-transplant recipient and donor variables associated with different transplant outcomes,[12-15] in addition to the significant impact of sociocultural and economic variables upon outcomes.[16-18]

Socioeconomic variables have been reported to influence health-related outcomes in Brazil. However, despite the socioeconomic disparities between the country's 26 states and five regions, the Brazilian transplant program has established itself as one of the largest in the world, allowing broad access to renal therapies.[19] In 2012, 5,385 of the 7,426 organ transplants performed in Brazil were kidney transplants.[20] However, not much has been published in the literature about the correlation between socioeconomic variables and post-transplant outcomes in Brazil. Studies have been carried out in a few centers in the country, and virtually all of them covered patients treated in the Southeast (80%) and South (16%) regions. In 2009, over 80% of the transplants done in Brazil were performed in the Southeast and South regions. In 2007, the states of São Paulo, Santa Catarina and Rio Grande do Sul had over 10 donors per million population, whereas in the Northern Brazilian states no organs were procured from deceased donors. Thus, despite the existence of a well-organized national transplant system and the increasing number of kidney transplants, differences in the number of transplants still persist as a reflex of the socioeconomic and cultural disparities seen between the regions of the country.[21]

Kidney function six months after transplant has been described as an independent risk factor associated with graft loss 24 months after transplantation in our patient population.[22] A retrospective study using data from the UNOS/OPTN enrolled 105,742 kidney transplant patients confirmed this finding and showed that poor renal function, estimated by serum creatinine levels > 1.5 mg/dL six and 12 months after transplantation, was correlated with decreased long-term graft survival.[23]

The estimated probability of having a successful kidney transplant using an intermediate endpoint such as renal function six months after transplant and selected variables of the Brazilian population may add value to patient counseling. Thus, the goal of this study was to develop a risk assessment scale considering pre-transplant recipient and donor variables to estimate the probability of success of kidney transplant procedures.

Materials and methods

Definition of Success

Patients with functional grafts and creatinine levels lower than or equal to 1.5 mg/dl six months after transplantation were deemed to have been successfully treated.

Study Design

This prospective cohort study enrolled deceased donor renal transplant patients seen between February and November of 2011. Subjects had to be 18 or older to be enrolled in the study. Multiple organ transplant patients were excluded. The selected patients were interviewed on the day of transplantation. Medical and demographic data were obtained from their charts. Patients were not required to give informed consent. The study protocol was approved by the UNIFESP Research Ethics Committee (Nº 1139/10).

Statistical Analysis

Sixty pre-transplant variables were selected and divided into seven categories: demographics, comorbidities, socioeconomic variables, workup, quality of life, donors, and medication (Chart 1).

Univariate analysis was performed for the 60 risk variables between the two study groups to identify the ones associated with success with a statistical significance level of 10%. Categorical variables were treated with the chi-square or Fisher's exact test. Numeric variables were analyzed using Student's *t* test for independent samples.

Multivariate analysis

Logistic regression analysis was used to identify pre-transplant variables independently associated with successful treatment. Initially, all variables associated with successful transplantation with a significance level of 10% were included in the logistic model. Then, the non-significant variables at a 5% significance level were excluded in the final calculation. Data was included based on order of magnitude as defined in forward stepwise regression.

The logistic regression equation for the studied population had ß coefficients for each of

Chart 1 Sixty pre-transplant variables

Demographic variables	Comorbidities
Age	Degree of dependence
Gender	Hypertension
Ethnicity	Diabetes
Renal disease etiology	Dyslipidemia
Time with kidney disease	Prior cardiovascular event
Mode of dialysis	Nutritional status
Time on dialysis	Peripheral vascular disease
Retransplant	Psychiatric disease
Prioritization	Hepatitis B, C, CMV
Panel reactive antibody	HIV
A, B, DR Mismatches	Drinking
	Smoking
Socioeconomic variables	**Workup**
Level of education	Abdominal waist
Patient monthly income	Weight (kg)
Household monthly income	Residual kidney function
Public aid/welfare	Peripheral pulses
Living conditions	Physical disability
Economic activity	Dental health
Time on leave from work	ECG
Quality of life	**Donor variables**
Patient impressions over his/her health	Age
Personal leve of satisfaction	Gender
Depression/Exhaustion	Weight (kg)
Performance of daily living activities requiring mild/moderate/ intense effort	Creatinine
Spouse	Etiology of death
Family support	Hypertension
Children	**Medication**
Assistance to take medication	Medication in use
	Number of medications
	Knowledge of medications

the risk variables identified in the logistic model. The exponential β coefficients [exp (β)] were interpreted as odds ratio (OR). This equation allowed the calculation of the probability of successful transplantation as an exponential function of the risk variables for any set of characteristics of a given individual.

The Hosmer-Lemeshow test was used to assess the degree of agreement of the equation when comparing the frequencies of the probabilities estimated by the equation and the observed frequencies of the probabilities. The area under the ROC curve was used to assess the ability of the equation to discriminate between success and non-success.

The scale

The method described by Sullivan[19] was used to build a scale using the variables identified by logistic regression analysis. Seven statistical adjustment steps were taken to allow the conversion of units of measurement between the two systems (logistic regression units into score units) while preserving the degree of association of each risk variable in estimating the probability of transplant success.

Step 1: the β regression coefficients for variables associated with success transplantation were obtained (β_0, β_1,...., βx). Step 2: variable values were stratified to create subcategories and determine the reference values for these subcategories (ω_{ij} i = number of risk variables, j = total number of subcategories for i risk variables). Step 3: variable subcategories of reference were obtained (ω_{ref}). Step 4: the distance in regression units between the other subcategories in relation to the subcategory of reference [$\beta_i (\omega_{ij} - \omega_{ref})$]. Step 5: a constant ($c$) was defined for the system (number of logistic regression units corresponding to 1 point in the scoring system). Step 6: the number of points in each variable subcategory was calculated using the system's β coefficient and constant c [$Points_{ij} = \beta_i (\omega_{ij} - \omega_{ref})/c$]. Step 7: the possible scores were multiplied by c and, through statistical adjustments, the probabilities of success were obtained.

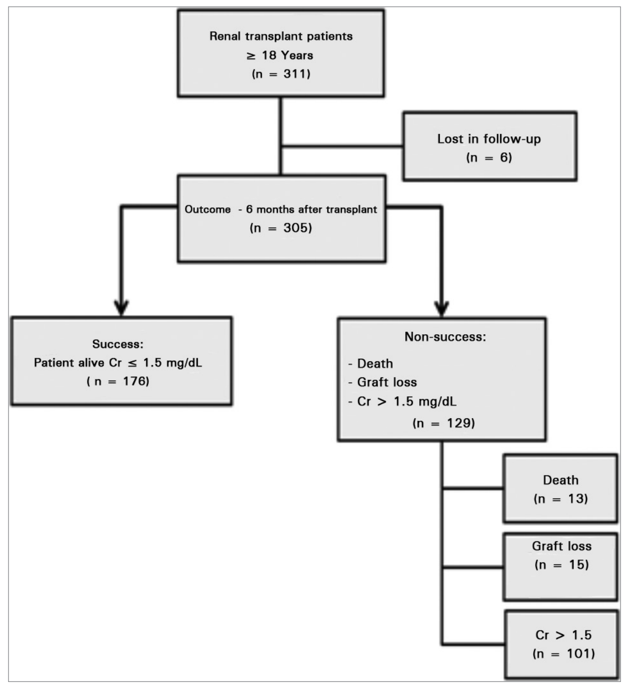
The intraclass correlation coefficient was used to quantify the degree of agreement between the estimated probabilities obtained via logistic regression and via the scoring system for each individual.

A significance level of 5% was used in all statistical tests. Software package SPSS 17.0 was used in statistical analysis.

Results

Six of the 311 enrolled patients were lost in follow-up by six months of transplantation. One hundred and seventy-six were deemed to have been successfully transplanted. Thirteen of the unsuccessful cases died, 15 suffered from graft failure, and 101 had serum creatinine levels > 1.5 mg/dL (Figure 1).

Figure 1. Algorithm for the studied population.



Patients had a mean age of 47.5 years; most were males (60.7%), Caucasian (47.9%), had CKD of unknown etiology (37%), underwent kidney transplantation for the first time (94.8%), and were treated through the Brazilian Public Heath Care System (87.3%). Before transplantation, most patients had been on hemodialysis (88.2%) for a mean of 4.3 years (Table 1).

The descriptive and frequency analysis findings of the 60 pre-transplant variables of the enrolled patients were divided into seven categories. Univariate analysis revealed that 21 of the 60 recipient and donor demographic, clinical and socioeconomic variables were associated with successful procedures. Five of these variables were demographic, two were socioeconomic,

Table 1 Patient demographic variables

Variable	Total (n = 305)	Success (n = 176)	Non-sucess (n = 129)	*p*
Age ± SD (min-máx), years	47.5 ± 12.3 (18-76)	48.6 ± 12.6 (19-76)	46 ± 11.9 (18-68)	0.68
Male gender, n (%)	185 (60.7)	86 (48.9)	99 (76.7)	0.00
Ethnicity, n (%)				0.61
Caucasian	146 (47.9)	87 (49.7)	59 (45.7)	
Brown	67 (22.0)	34 (19.3)	33 (25.6)	
Black	78 (25.6)	46 (26.1)	32 (24.8)	
Asian	14 (4.6)	9 (5.1)	5 (3.9)	
Etiology of CKD, n (%)				0.31
Undetermined	113 (37.0)	59 (33.5)	54 (41.9)	
Hypertensive nephrosclerosis	31 (10.2)	23 (13.1)	8 (6.20)	
Polycystic kidney disease	45 (14.8)	29 (16.5)	16 (12.4)	
Diabetic nephropathy	40 (13.1)	22 (12.5)	18 (14.0)	
Glomerulonephritis	52 (17.0)	30 (17.0)	22 (17.1)	
Others	24 (7.9)	13 (7.4)	11 (8.5)	
Hemodialysis, n (%)	269 (88.2)	153 (86.9)	116 (89.9)	0.42
Time on dialysis ± SD (min-máx), years	4.3 ± 3.4 (0-20)	4.2 ± 3.6 (0-20)	4.3 ± 3.1 (0.25-20)	0.89
Time on dialysis, n (%)				0.10
≤ 2 years	109 (35.7)	68 (38.6)	41 (31.8)	
2-10 years	174 (57)	92 (52.3)	82 (63.6)	
> 10 years	22 (7.2)	16 (9.1)	6 (4.7)	
Time on conservative treatment ± SD, years	3.7 ± 6.4	4.5 ± 7.3	2.7 ± 4.8	0.01
Health insurance, n (%)	68 (22,3)	44 (25.0)	24 (18.6)	0.19
First kidney transplant, n (%)	289 (94.8)	164 (93.2)	125 (96.9)	0.15
Prioritized, n (%)	10 (3.3)	7 (4.0)	3 (2.3)	0.53
Panel-reactive antibody ± SD (min-max), %	15.3 ± 26.3 (0-100)	18.1 ± 27.9 (0-99)	11.4 ± 23.5 (0-100)	0.02
Panel ≥ 30%, n (%)	60 (19.7)	44 (25)	16 (12.4)	0.01
Zero HLA-A MM, n (%)	56 (18.4)	35 (19.9)	21 (16.3)	0.42
Zero HLA-B MM, n (%)	69 (22.6)	40 (22.7)	29 (22.5)	0.96
Zero HLA-DR MM, n (%)	238 (78)	145 (82.4)	93 (72.1)	0.03
Zero HLA A, B, DR MM, n (%)	23 (7.5)	16 (9.1)	7 (5.4)	0.80

three were related to quality-of-life, two to comorbidity, three to workup, and six were donor variables (Table 2).

The individual impact of these 21 variables was analyzed through logistic regression analysis, and ten were independently associated with outcome of transplantation. Two of these ten variables were socioeconomic, two were demographic, one was related to comorbidities, one to workup, two to quality of life and two were donor variables (Table 3).

The β coefficients of the ten variables were used to build a logistic regression equation (Figure 2) and estimate the transplant probability of success.

The Hosmer-Lemeshow test showed no differences between the probability frequencies estimated using the equation and the frequencies of the observed probabilities for the 305 patients (p = 0.672). The area under the ROC curve was 0.817, indicating that the equation with the ten pre-transplant variables had great discriminatory power to tell successfully from unsuccessfully treated patients.

The scoring system derived from the ten variables independently associated with success cases is shown on Table 4. The setup of the scale takes into account the stratification of categorical and

Table 2 Twenty-one variables associated with transplant success in univariate analysis ($p \leq 0.10$)

Variable	Success (n = 176)	Non-success (n = 129)	*p*
Demographics			
Recipient gender, n (%)			0.00
Male	90 (51.1)	30 (23.3)	
Female	86 (48.9)	99 (76.7)	
Time on dialysis, n (%)			0.09
≤ 2 years	68 (38.6)	41 (31.8)	
> 2 years	108 (61.4)	88 (68.2)	
Time on conservative treatment ± SD, years	4.5 ± 7.3	2.7 ± 4.8	0.01
Panel reactive antibody, n (%)			0.00
≥ 30%	44 (25)	16 (12.4)	
< 30%	132 (75)	113 (87.6)	
DR Mismatch, n (%)			0.03
Zero	145 (82.4)	93 (72.1)	
Some MM	31 (17.6)	36 (27.9)	
Socioeconomic variables			
Public aid/welfare, n (%)			0.03
Dependent	112 (63.6)	97 (75.2)	
Independent	67 (37.4)	32 (24.8)	
Patient monthly income, n (%) R$*			0.00
< 3000,00	134 (76.1)	75 (58.1)	
≥ 3000,00	42 (23.9)	54 (41.9)	
Quality of life			
Children, n (%)			0.00
Yes	150 (85.2)	92 (71.3)	
No	26 (14.8)	37 (28.7)	
Family support, n (%)			0.02
Yes	148 (84.1)	95 (73.6)	
No	28 (15.9)	34 (26.4)	
Patient thinks he/she is in GOOD health, n (%)			0.05
Yes	169 (96)	117 (90.7)	
No	7 (4)	12 (9.3)	
Comorbidities			
CMV serology, n (%)			0.01
Positive	6 (3.4)	13 (10.1)	
Negative	170 (96.6)	116 (89.9)	
Peripheral arterial disease, n (%)			0.09
Present	5 (2.8)	9 (7.0)	
Absent	171 (97.2)	120 (93)	
Workup			
Weight ± SD (min-max), kg	66 ± 12.6 (36-104)	70 ± 14.2 (41-108)	0.00
ECG alterations, n (%)			0.00
Yes	60 (34.1)	69 (53.5)	
No	116 (65.9)	60 (46.5)	
Physical disability n (%)			0.04
Yes	23 (13.1)	28 (21.7)	
No	153 (86.9)	101 (78.3)	

Continued Table 2.

Donor			
Donor gender, n (%)			0.05
Male	121 (68.7)	75 (58.1)	
Female	55 (31.3)	54 (41.9)	
Donor age ± SD (min-max), years	43.9 ± 43.9 (18-74)	50 ± 11.8 (19-74)	0.00
Donor weight ± SD (min-max), kg	75.4 ± 13.6 (45-120)	72.5 ± 14.4 (45-120)	0.08
Donor death etiology, n (%)			0.00
Cardiovascular disease	82 (46.6)	84 (65.1)	
Other	94 (53.4)	45 (34.9)	
Donor hypertension, n (%)			0.05
Yes	58 (33.0)	57 (44.2)	
No	118 (67.0)	72 (55.8)	
Expanded criteria donor, n (%)			0.06
Yes	48 (27.3)	48 (37.2)	

* Income of US$ 1,260.00.

Table 3 Ten variables independently associated with transplant success in the final logistic regression model

	ß coefficient	*p*	Odds ratio (OR)	95% Confidence Interval for odds ratio
Recipient gender				
Female	0.99	0.004	2.69	1.37-5.30
Male (ref.)	0.00	-	1.00	-
Recipient weight	-0.04	0.002	0.96	0.94-0.99
DR Mismatch				
Zero	1.34	0.000	3.80	1.88-7.69
Some MM (ref.)	0.00	-	1.00	-
Public aid/welfare				
Yes (ref.)	0.00	-	1.00	-
No	0.63	0.045	1.89	1.02-3.52
Patient monthly income				
< R$ 3.000 (ref.)	0.00	-	1.00	-
≥ R$ 3.000	1.45	0.004	4.26	1.59-11.39
Children				
Yes	1.06	0.004	2.90	1.42-5.93
No (ref.)	0.00	-	1.00	-
Family support				
Yes	0.77	0.028	2.17	1.09-4.33
No (ref.)	0.00	-	1.00	-
ECG alterations				
Yes (ref.)	0.00	-	1.00	-
No	0.95	0.002	2.59	1.42-4.72
Donor death etiology				
Other	0.65	0.030	1.92	1.07-3.48
Cardiovascular disease (ref.)	0.00	-	1.00	-
Donor age	-0.04	0.001	0.96	0.94-0.98
Constant	1.05	0.339	2.86	-

Figure 2. Logistic regression equation.

$$\frac{1}{1 + 2.718^{-(1.05 + 0.99 \times \text{Gender} + 1.34 \times \text{DR MM} + 0.63 \times \text{Welfare} + 1.45 \times \text{Monthly Income} + 1.06 \times \text{Children} + 0.77 \times \text{Family support} + 0.95 \times \text{ECG} + 0.65 \times \text{Cause of Death} - 0.004 \times \text{Recipient weight} - 0.04 \times \text{Donor age} + E)}}$$

continuous variables into subcategories. A variation of five years on donor age in relation to transplant probability of success was considered as the C in our scale. Therefore, one point in the score corresponded to an increase in transplant probability of success equivalent to receiving a graft from a kidney donor five years younger. Table 5 exemplifies the allocation of points for the two profiles of patients with the highest and the lowest scores. Scores ranged from 0 to 56 points. In the studied population, scores ranged from eight (probability of success of 1.9%) to 46 points (probability of success of 98.5%) (Table 6).

The agreement between the probabilities estimated with logistic regression and the probabilities calculated via the scale was deemed adequate [0.982, 95% CI (0.978 to 0.986)].

Discussion

This study proposed a pre-transplant scale with 10 demographic donor and recipient variables to estimate the probability of success of kidney transplants. Success was defined as the patient being alive six months after transplantation, having a functional graft and creatinine levels below or equal to 1.5 mg/dL.

The clinical application of the scale did not require the use of statistical software packages or calculators. The assignment of integer values (points) to the 10 risk variables based on how they correlated to patient outcomes combined advanced statistical methods and logistic regression analysis.[24]

A review published by Kasiske in 2010 revealed substantial variance in the findings reported in 20 studies that used multivariate analysis to calculate the risks associated with various renal transplant outcomes. The analyzed

Table 4 Scores

Risk variables	Value (ω)	Coefficient (β)	β_i (ω-ω_{ref})	Score = β_i (ω-ω_{ref})/C
Gender		0.992		
Female	1		0.99	5
Male (ref.)	0 = ω_{ref}		0.00	0
DR Mismatch		1.336		
Zero	1		1.36	6
Some MM (ref.)	0 = ω_{ref}		0.00	0
Public aid/welfare		0.636		
Yes (ref.)	0 = ω_{ref}		0.00	0
No	1		0.63	3
Patient monthly income		1.45		
< R$ 3000 (ref.)	0 = ω_{ref}		0.00	0
≥ R$ 3000	1		1.44	7
Children		1.07		
Yes	1		1.07	5
No (ref.)	0 = ω_{ref}		0.00	0
Family support		0.77		
Yes	1		0.77	4
No (ref.)	0 = ω_{ref}		0.00	0
ECG alterations		0.95		
Yes (ref.)	0 = ω_{ref}		0.00	0
No	1		0.95	4

CONTINUED TABLE 4.

Recipient weight		-0.04		
≤ 50	43.0		2.07	10
50 ---| 60	55.5		1.57	7
60 ---| 70	65.5		1.17	5
70 ---| 80	75.5		0.76	4
> 80 (ref.)	94.5 = w_{ref}		0.00	0
Donor cause of death				
Other	1	0.65	0.65	3
Cardiovascular disease (ref.)	0 = w_{ref}		0.00	0
Donor age		-0.04		
≤ 30	24.0		1.86	9
30 ---|40	35.5		1.37	6
41 ---|50	45.5		0.94	4
51 ---|60	55,5		0.51	2
> 60 (ref.)	67.5 = w_{ref}		0.00	0
Donor age		-0.04		
≤ 30	24.0		1.86	9
30 ---|40	35.5		1.37	6
41 ---|50	45.5		0.94	4
51 ---|60	55.5		0.51	2
> 60 (ref.)	67.5 = w_{ref}		0.00	0
Constant		1.05		

TABLE 5 PATIENT SCORES - ID 200 & ID 70

Variables	Scores	Profile ID = 200	Profile ID = 70
Female	5	1	0
Zero DR mismatch	6	1	0
No public aid/welfare	3	1	0
Patient income ≥ R$ 3,000.00	7	1	0
Patients with children	5	1	0
Good family support	4	1	0
No ECG alterations	4	1	1
Recipient weight			
≤ 50	10	0	0
50 ---| 60	7	0	0
60 ---| 70	5	0	0
70 ---| 80	4	0	1 (74 kg)
> 80	0	1 (84 kg)	0
Other donor causes of death	3	1	0
Donor age			
≤ 30	9	1 (20 years)	0
30 ---|40	6	0	0
41 ---|50	4	0	0
51 ---|60	2	0	0
> 60	0	0	1 (66 years)
Total Score		46	8

1 = Yes; 0 = No.

Table 6 Success probabilities based on total scores

Score	Estimated probability	Score	Estimated probability
0	0.004	29	0.637
1	0.004	30	0.685
2	0.005	31	0.729
3	0.007	32	0.769
4	0.008	33	0.805
5	0.010	34	0.836
6	0.013	35	0.863
7	0.016	36	0.886
8	0.019	37	0.906
9	0.024	38	0.923
10	0.029	39	0.937
11	0.036	40	0.948
12	0.044	41	0.958
13	0.055	42	0.966
14	0.067	43	0.972
15	0.081	44	0.977
16	0.099	45	0.982
17	0.119	46	0.985
18	0.144	47	0.988
19	0.172	48	0.990
20	0.204	49	0.992
21	0.241	50	0.994
22	0.282	51	0.995
23	0.328	52	0.996
24	0.376	53	0.997
25	0.427	54	0.997
26	0.480	55	0.998
27	0.534	56	0.998

combinations of variables relative to recipient and/or donor risks were presented in the form of algorithms, scales, and tables.[25-29] However, the complex mathematical equations described in some of these studies have not been used in the clinical practice of transplant centers.

van Walraven *et al.* also used the methodology described by Sullivan to build a scale to estimate the risk of death within five years for kidney transplant candidates on dialysis. The 12 variables used referred only to recipients.[9] Interestingly, except for recipient age, the variables identified by van Walraven *et al.* did not match the ones described in our study. Such observation speaks of the specific associations held between variables and analyzed outcomes. The variables in the scale described by van Walraven *et al.* correlated with the long-term survival endpoint analyzed by the author. The ten variables considered in our study were associated with patient survival and satisfactory renal function six months after renal transplantation.

The two donor variables associated with transplant success, age and etiology of death, were in agreement with previous literature reports.[30,31] A four percent reduction in the chance of transplant success was observed when donor age was added by one year starting from the age of 30. Moreover, recipients of kidneys coming from donors who died of cardiovascular disease were 50% less likely to have successful transplants than recipients of kidneys from donors who died of other causes. Previous reports indicate that donor age and cause of death were largely responsible for the variability of kidney transplant outcomes, as both have been directly related to the quality of the transplanted kidney.[32]

Weight was the only of the 18 assessed comorbidities correlated with transplant outcome. A longer follow-up period would be necessary to clarify the impact of chronic comorbidities and insidious progression of transplant outcomes. This study was designed to estimate kidney transplant viability, not long-term patient survival. The short time for which patients were followed did not allow the manifestation of such association.

A noteworthy four of the eight recipient variables associated with successful transplantation (public aid/welfare, patient monthly income, children, and family support) were related to socioeconomic and quality-of-life variables. Recipients off welfare had twice the chance of success than subjects on welfare. Additionally, patients with monthly incomes over R$ 3,000 were four times more likely to have successful transplants. Lower socioeconomic status has been associated with increased incidence of chronic diseases, progression of renal disease, inadequate dialysis, reduced chances of having access to transplantation, and worse health outcomes in general.[33] Poorer patients also complied less with drug therapy and had worse outcomes after transplantation.[34]

Patients with children were three times more likely to have successful transplants than childless individuals, and patients supported by their families were twice more likely to have successful outcomes, indicating that factors related to quality of life impacted renal transplant outcomes. We assume that patients with children belong to more stable families. In previous studies, dialysis and transplant patients with supportive families, stable marriages, jobs, and higher levels of education were more satisfied with the course of therapy and had higher mental state scores.[33,34] These factors are believed to be associated with greater compliance to treatment and better outcomes in the long run.[35,36] Our results showed that recipients with lower socioeconomic and quality-of-life scores had lower chances of having successful transplants. These characteristics are not routinely assessed or recorded because they are subjective and difficult to quantify. However, as shown by our results, non-traditional risk factors were associated with worse short-term outcomes and had a bigger impact than anticipated.

The scale developed in this study performed to satisfaction when used in our population. It offered good discrimination between patients successfully and unsuccessfully transplanted, with an accuracy of 81.7%. Additionally, no differences were found in the frequencies of estimated and observed probabilities of the 305 enrolled patients.

The estimation of probable treatment success rates before the start of therapy has been pursued in medical practice for many years. However, the decision to perform a transplant has been grounded on non-quantitative information derived from clinical experience and scientific knowledge. Despite the proven long-term benefits of renal transplantation, the procedure is still associated with high perioperative mortality rates.

Death rates during the transition period of dialysis and deceased donor kidney transplants (one to three months after transplantation) were higher than the mortality rate of patients on the transplant waiting list (9.57 *versus* 6.38 deaths/100 patient-years).[36] The rate of perioperative cardiovascular events was eight times higher than the relatively constant rates reported for patients on dialysis (39.6 *versus* 5.3 to 6.6 cardiovascular events/100 patient-years).[37] In contrast, in Brazil infection still prevails as the main cause of death among patients.[38] Infectious complications were observed in 49% of kidney recipients in the first year after transplantation and, in addition to immunosuppressive therapy, factors related to socioeconomic conditions, health and hygiene, and prior epidemiological exposure to contagious diseases contributed to these results.

Studies on the use of scales in routine pre-transplant examination are generally scarce, and papers considering Brazilian patient populations are virtually inexistent. The growing interest in the development of scales may help determine whether new instruments have better prognostic accuracy than clinical assessment alone in categorizing patients into different prognostic groups.

However, the implementation of theoretical models should always be carefully considered and performed with caution, as there is a distance between the statistical performance of the scale and what it actually delivers. The variables considered in this study cannot be used to predict outcomes, as they rely merely on a relationship of association. To do so, clinical markers must be evaluated for their positive predictive value[39,40] within a relevant assessment context. The validation of the scale discussed in this paper is underway in the second stage of this study. The objective is to ascertain whether the same degree of agreement, discrimination, and correlation obtained in this study will be repeated for a different cohort of patients. In order for this scale to be used in clinical practice, score categories might have to be linked to acceptable risk levels, thus allowing the quantification of pre-transplant risk in a continuous scale, differently from what would happen if one single cutoff value were defined to decide whether a patient should undergo transplantation.

The logistic regression model and the sample of the population used to build the scale limit[40] its use. The scale was developed for a population that is not distinguished by any particular characteristic. Therefore, its results cannot be extrapolated or applied to other specific segments of the population. Additionally, the scale can only be used to assess recipients of deceased donor kidneys with complete information on 10 analyzed variables.

This is the first Brazilian study to use logistic regression analysis for the development of a risk assessment scale for pre-renal transplant patients. We believe that treatment individualization requires knowledge of considerably accurate quantitative information, and probabilistic models may be used to this end.[41]

Conclusion

The scale with ten demographic donor and recipient variables used in this study was able to estimate the probability of patients in our population having successful renal transplants. Four of the ten variables were significantly correlated with impact in the socioeconomic category, thus reinforcing the need to create prognostic scales that take clinical variables of our own population into account.

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