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Kidney Donor Profile Index (KDPI) Does Not Accurately Predict the Graft Survival of Pediatric Deceased Donor Kidneys

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Abstract

Background—The new deceased donor kidney allocation algorithm uses a Kidney Donor Profile Index (KDPI) based on donor characteristics to predict graft survival and divides kidneys into 4 quality groups (i.e., KDPI-A, -B, -C, and -D). Pediatric kidneys constitute 10–12% of deceased donor kidneys. We hypothesized that KDPI would not accurately predict pediatric donor graft survival and superior predictive models could be created.

Methods—Scientific Registry of Transplant Recipients data for years 2000–2010 for transplants from child (<10 years) and adolescent (10–17 years inclusive) donors into first-time adult recipients were analyzed with graft failure as the principle outcome. Two novel indices, Child Donor Index (CDI) and Adolescent Donor Index (ADI), were developed using stepwise variable deletion to identify significant model covariates in a Cox Regression. Pediatric donor kidneys were then classified into the four quality groups based on both KDPI and CDI/ADI scores. The performance of the KDPI, CDI and ADI models were compared with respect to the four quality groups defined by the new allocation system.

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3. JR Thistlethwaite, Jr: Participated in research design, participated in data analysis and in data interpretation, participated in critical revisions of the paper.

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Results—KDPI did not effectively discriminate between quality groups ($p > 0.05$ for all but one comparison) in Kaplan-Meier survival analyses. CDI and ADI included novel variables (e.g., body mass index percentiles) and successfully discriminated between quality groups ($p < 0.05$ by log rank test). The Net Reclassification Index showed improvement when switching from KDPI to CDI and ADI, with values of 0.09 ($p < 0.001$) and 0.073 ($p < 0.001$) respectively.

Conclusion—KDPI does not accurately predict pediatric kidney graft survival. Alternative indices can improve allocation efficiency.

Introduction

To increase the efficiency of deceased donor kidney allocation, the Organ Procurement and Transplantation Network (OPTN) implemented a new kidney allocation system that uses a Kidney Donor Profile Index (KDPI). KDPI is designed to predict kidney graft performance in adult recipients based on ten donor characteristics. A Kidney Donor Risk Index (KDRI) is generated from a multivariate Cox Regression modified from that of Rao et al., (1) and the KDRI of each kidney is then mapped into a KDPI scale from 1 (Best) to 100 (Worst). Donor kidneys are divided into four quality groups by KDPI: (KDPI-A: $\leq 20\%$; KDPI-B: $>20\%$ but $<35\%$; KDPI-C: 35% but $\leq 85\%$; and KDPI-D: $>85\%$). Each donor quality group is to be allocated to particular candidate groups according to a “sequence” specified by the OPTN. (2) See Table 1 for a lexical summary of allocation principles.

Pediatric deceased donor kidneys constitute between 10–12% of the deceased donor kidney supply (3) and are allocated using the same criteria as adult kidneys under the new allocation policy. The OPTN asserts that KDPI can be used to allocate pediatric donor grafts appropriately. (4) Regarding very young or small donors, the OPTN states that “[small donors] whose kidneys are generally smaller and have less renal mass, can have high [worse] KDPI values.” (4) However, at least one factor known to be predictive of young pediatric donor kidney performance from the original Rao model—en bloc vs. single kidney transplant (SKT) status (5)—was not included in the KDPI model. Also, in the KDPI algorithm, continuous covariates for donor size were used despite evidence to suggest that categorical covariates may be more predictive of outcome for pediatric donors. (5–8) We hypothesized that 1) KDPI would not accurately predict graft survival of pediatric donor kidneys; and 2) alternative indices could be developed that could outperform KDPI for pediatric donor kidneys.

Materials and Methods

We elected to divide the pediatric kidneys into two groups based on prior work by Opelz and Döhler who suggested that pediatric kidney performance was best evaluated by splitting kidneys into younger (<11 years) and older (11–17) pediatric kidneys based on modeling performed using a mainly European dataset (9). However, a preliminary univariate Kaplan-Meier analysis of 5-year graft survival of pediatric deceased donor kidneys by donor age using the United States OPTN Standard Transplant Analysis and Research (STAR) dataset (10) (based on transplants performed between 1/1/2000 to 12/31/2005 with follow-up through 12/31/2013) suggested 10 years was a more appropriate cut off, so we defined child donors as <10 years and adolescent donors as 10–17 years. (11)

For our principle analysis, outcome and donor data on kidney-alone deceased donor kidney transplants into first-time adult recipients performed between 1/1/2000 to 12/31/2010 were obtained from the Scientific Registry of Transplant Recipients (SRTR) dataset. This dataset is more comprehensive than the STAR dataset and includes submissions to the OPTN by transplant centers, Organ Procurement Organizations (OPOs), and histocompatibility laboratories, data collected by the Centers for Medicare and Medicaid Services regarding return to dialysis among transplant recipients, and mortality information from the Social Security Death Master File. Follow-up for recipients was complete through 12/31/2014. (3)

For all donors (adult and pediatric), the KDRI_Rao value was calculated according to the equation available on the OPTN website.(4) All donors in the time period were rank ordered according to KDRI_Rao and a KDRI median value for the 2000–2010 time period was 1.185. We then generated normalized KDRI values to the 2000–2010 time period in the fashion described on the OPTN website and determined that the 20%, 35%, and 85% KDRI values corresponded to a normalized KDRI of 0.755, 0.871 and 1.432 respectively. Each donor was distributed into the appropriate KDPI group (see Table 1) based on the donor's normalized KDRI value. The range of KDPI-predicted 5-year graft survivals for all (adult and pediatric) donor kidneys based on KDPI group was developed using a Cox regression with log (KDRI) as the sole independent variable. KDPI-A (which includes the top 20% of donor kidneys) contained kidneys with a 5-year predicted graft survival of >78.4%, KDPI-B (which includes those kidneys between 20 and 35%) contained kidneys with a 5-year predicted graft survival of >75.5% but 78.4%, KDPI-C (which includes kidneys 35% but 85%), contained kidneys with a 5-year predicted graft survival of >62.8 % but 75.5%, and KDPI-D (which includes kidneys in the bottom 15%), contained kidneys with a 5-year predicted graft survival of 62.8%. Kaplan-Meier plots of graft survival for child (<10 years) and adolescent (10–17 year inclusive) donors by KDPI quality (A, B, C, or D) group were made and 5-year graft survival estimates were generated.

Manual stepwise variable deletion was then used to create two separate Cox regressions models for child and adolescent donors with graft failure as the principle outcome. The following donor factors, including all variables used to generate KDRI, were evaluated in the initial models: age, en bloc vs. single kidney transplant (SKT), mechanism of death, circumstance of death, heart-beating or non-heart beating, race, gender, donor infection(s), body mass index (BMI) percentiles (Centers for Disease Control and Prevention (CDC) gender-adjusted weight-for-age growth chart), weight, height, Creatinine (Cr), Creatinine clearance (CrCl), glomerular filtration rate (GFR), vasopressor support, inotropic support, proteinuria, diuretic administration, steroid administration, cardiac arrest, duration of resuscitation for donor cardiac arrest, and history of diabetes. For significant continuous covariates, the functional form was determined by refitting the model with the continuous covariate divided into categories and attempts were made to estimate non-linear effects within categories with linear splines. If the functional form was unable to be improved upon with linear splines, the categories were retained. Model covariates that did not significantly affect graft failure ($p>0.1$) were eliminated, similar to the development of KDRI by Rao et al. (1) Using the baseline hazard function and the prognostic index of each donor, we generated predicted survivals for the Child Donor Index (CDI) and the Adolescent Donor Index (ADI). Based on these predicted survivals, kidneys were divided into groups A, B, C

and D groups designed to match the predicted KDPI 5-year graft survival ranges for all donor kidneys. Graft survival of each group was compared to the graft survival of the other groups by pairwise log rank test.

The performance of KDPI, CDI and ADI was directly compared. First, the 5-year survivals of the A, B, C, D groups as classified by CDI/ADI and KDPI were compared to the reference 5-year survival (the mean 5-year survival of each KDPI classified A, B, C, and D group for all donors-adult and pediatric) by the binomial test. Second, performance nomogram plots of Kaplan-Meier 5-year graft survival by Cox-predicted 5-year graft survival were made for child and adolescent donors respectively. Conventionally one would divide child donor kidneys into deciles based on predicted CDI score to compare Cox-predicted vs. Kaplan-Meier 5-year graft survival. Due to categorical factors, this was not feasible, but rather 7 CDI kidney groups were defined and plotted. The same procedure was followed for adolescent donor kidneys, and again only seven groups were created based on predicted ADI scores. Next, for both child and adolescent donors, seven equal sized groups rank ordered by KDPI score were identified and KDPI predicted vs. Kaplan-Meier 5-year graft survivals for each group were plotted. CDI, ADI and KDPI were then tested using the Hosmer-Lemeshow goodness-of-fit test calculated using Cox model predictions and Kaplan-Meier survival. Lower p-values are associated with a significant difference between model predictions and Kaplan-Meier survivals and signify a poor model fit.(12).

Next, the Net Reclassification Improvement (NRI) was calculated based on switching from KDPI to CDI/ADI. (13) NRI is a measure of valid reclassification between risk groups when improving upon predictive models. The KDPI-A, -B, -C, and -D groups of distribution sequences were used as the defined risk groups (see Table 1). As proposed by Pencina et al., the NRI was defined to be significant if p-value <0.01.(13)

Finally, we performed cross-validations of both CDI and ADI. The respective data sets were divided in half five times similar to what was done by Rao et al.(1) For each split, we fitted the models to one half (derivation set) and calculated predicted survivals for the other half (validation set) based on the derivation set model. Each derivation set was then divided into four risk groups, each composed of >10% of the sample. Four groups with the same range of predicted survivals were then identified in the corresponding validation set. Kaplan-Meier vs. model predicted survival for each group was plotted and a Hosmer-Lemeshow goodness-of-fit test (12) was performed for both the validation and derivation sets for both CDI and ADI.

All data analyses were performed using SPSS v22. The University of Chicago institutional review board exempts studies using deidentified databases.

Results

There were a total of 83,390 kidney alone deceased donor transplants from January 1, 2000 through December 31, 2010 to first-time adult recipients, 73,286 of these transplants were from adult donors and 10,104 were from pediatric donors (<18 years of age). This included

3,725 child donors with 916 graft failures through five years of follow-up and 6,379 adolescent donors with 1,375 recorded graft failures through five years of follow-up.

Child Donors

Child donors had an average normalized KDRI of 1.16, corresponding to a mean KDPI of 66% and a KDPI predicted 5-year graft survival of 68.8% (based on a Cox regression with log KDRI as the sole covariate for the 2000–2010 time period). The Kaplan-Meier 5-year graft survival for all child donors was 73.5% (see Figure 1). Only 0.4% and 4.6% of child donor kidneys were classified as KDPI-A and KDPI-B respectively. Most child donor kidneys (84.4%) were classified as KDPI-C and the remaining 10.1% were classified as KDPI-D. There were **no** significant differences in 5-year graft survival among the four KDPI groups ($p = 0.05$ for all comparisons, see Figure 2A).

The final CDI Cox regression included the covariates: age (as a categorical variable <1 year, 1–4 years, and >4 years), underweight for age (<25th percentile of CDC gender-adjusted weight-for-age growth chart), history of diabetes, en bloc, seizure as mechanism of death, and pulmonary infection at time of death (Table 2). We found that the continuous donor age covariate used in KDPI (which assumes a proportional scaling of the hazard with each change in year of life) became non-significant in the Cox regression when a categorical age covariate (which assigns different risks of graft failure to groups <1 year, 1–4 years, and >4 years) was included. Kidneys from donors <1 year had uniquely worse performance due to very early graft failure (see Figure S1). As previously reported, (5,7,14,15), a substantial survival advantage was found for en bloc grafts (adjusted Hazard ratio (HR) 0.661, $p < 0.001$) (see Figure S2). The categorical underweight for age covariate (<25th percentile of CDC gender-adjusted weight-for-age growth chart) was found to predict graft performance better than a continuous weight covariate used in KDPI (adjusted HR 1.141 if donors were light for age, $p = 0.082$). The underweight for age categorical covariate in the Cox regression model resulted in continuous weight and height covariates used in KDPI to be non-significant at a $p > 0.1$ level. A histogram of CDI predicted 5-year survival is shown in Figure S3.

Kaplan-Meier plots of graft survival of the A, B, C, D groups as defined by predicted CDI survival (Figure 2B) demonstrates the discriminatory power of CDI. CDI-A was composed of the top 15.6% of child donor kidneys with a Kaplan-Meier 5-year graft survival of 80.0%. CDI-B was composed of 20.4% of child donor kidneys with a Kaplan-Meier 5-year graft survival of 77.0%. CDI-C and CDI-D were composed of 60.9% and 7.5% of kidneys, with Kaplan-Meier 5-year graft survivals of 71.7% and 55.2% respectively. Unlike the KDPI A, B, C, and D quality groups, **all** CDI quality groups had significantly different graft survival from each other ($p < 0.014$, see Figure 2B) except for CDI-A and CDI-B ($p = 0.06$ by pairwise log rank test).

Table 3 displays the mean Kaplan-Meier estimated 5-year survival for each A, B, C, and D group as classified by KDPI or CDI as well as the size of each group. For comparison, column 3 provides 5-year kidney graft survival by classification group for all donor (adult and pediatric) grafts as a reference. CDI classified 31% more child donors as A or B. There was no significant difference between each CDI classified group survival and the reference

survival ($p < 0.05$ by binomial test). For KDPI, there was a significant difference for all groups except group B ($p < 0.05$ by binomial test).

Figure 2C demonstrates the performance of CDI compared to KDPI in a nomogram of Kaplan-Meier survival versus model predicted survival. KDPI typically predicts graft survival to be substantially erroneously low. In contrast, CDI accurately predicts survival, with very small differences between predicted and Kaplan-Meier survival for all groups. A Hosmer-Lemeshow goodness-of-fit test demonstrated a poor fit for KDPI ($p < 0.0001$) and indicated that CDI is well calibrated to the Kaplan-Meier survival ($p = 0.916$). Overall, switching prediction from KDPI to CDI changed the predicted 5-year graft survival by more than 5% for 50.2% of child donor kidneys and by more than 10% for 22.1% of child donor kidneys (see Figure 2D). The NRI for switching from CDI to KDPI was 0.09 ($p < 0.001$).

Cross-validation testing for CDI revealed a good fit in all of the five validation datasets (p -values of 0.11, 0.16, 0.21, 0.13, 0.19) by the Hosmer-Lemeshow goodness-of-fit. See Figure S4 for an example performance nomogram.

Adolescent Donors

Adolescent donors had a mean KDRI of 0.74, corresponding to a KDPI of 18%, and a predicted 5-year graft survival of 78.2% (based on a Cox regression with log KDRI as the sole covariate for the 2000–2010 time period). The actual Kaplan-Meier 5-year graft survival for all adolescent donors was 77.1% (Figure S5). Most adolescent donor kidneys were classified as KDPI-A (61.5%) or KDPI-B (25.3%) with Kaplan-Meier 5-year graft survivals of 78.3% and 76.6% respectively. Only 13.0% of adolescent donor kidneys were classified as KDPI-C with a Kaplan-Meier 5-year graft survival of 72.9%. Almost no adolescent donor kidneys (0.1%) were classified as KDPI-D with a Kaplan-Meier 5-year graft survival of 70.2% (Figure 3A). There was a significant difference between KDPI-A and KDPI-C ($p = 0.001$ by log rank test), but no other significant differences between KDPI groups.

The final ADI Cox regression included the donor factors of African American ethnicity, DCD, donor height > 180 cm, BMI percentile (CDC gender- and age-adjusted), history of diabetes, and suicide as a circumstance of death (Table 4). For ADI, both BMI percentiles and donor height were found to have independent categorical relationships to graft failure for adolescent donor kidneys. Kidneys from adolescent donors with a BMI in the 50th to 95th percentile (CDC gender- and age-adjusted) had superior graft survival to obese adolescents (BMI $> 95^{\text{th}}$ percentile) or those with lower BMIs percentiles ($< 50^{\text{th}}$ percentile). Kidneys from adolescent donors taller than 180 cm had significantly increased graft survival by log rank test compared to all adolescents shorter than 180 cm (Figure S6). Inclusion of these categorical size covariates in the model resulted in the continuous donor age, weight, and height covariates used in KDPI to become non-significant ($p > 0.05$). A histogram of ADI predicted 5-year survival is shown in Figure S7.

Kaplan-Meier plots of graft survival of the A, B, C, D groups as defined by predicted ADI survival (Figure 3B) demonstrates the discriminatory power of ADI. ADI-A and ADI-B were composed of 53.7% and 27.5% of adolescent donor kidneys with Kaplan-Meier 5-year

graft survivals of 80.1% and 75.4% respectively. ADI-C was composed of 18.1% of adolescent donor kidneys with a Kaplan-Meier 5-year graft survival of 71.4%. Only 0.6% of adolescent donor kidneys were classified as ADI-D, with a Kaplan-Meier 5-year graft survival of 64.4%. Unlike the KDPI defined A, B, and C groups, the ADI A, B, and C groups had significantly different graft survival from each other ($p < 0.02$).

Table 5 displays the mean Kaplan-Meier estimated 5-year survival for each A, B, C, and D group as classified by KDPI or ADI as well as the size of each group. For comparison, column 3 provides 5-year kidney graft survival by classification group for all donor (adult and pediatric) grafts as a reference. KDPI group C kidneys had an erroneously high 5-year survival ($p=0.04$ by binomial test). ADI classified more kidneys as C-group than KDPI.

Figure 3C demonstrates the performance of ADI compared to KDPI in a nomogram of Kaplan-Meier survival versus model predicted survival. KDPI tended to overpredict adolescent donor survival when compared to Kaplan-Meier survival. A Hosmer-Lemeshow goodness-of-fit test demonstrated a poor fit for KDPI ($p=0.006$) and an adequate fit for ADI ($p=0.995$). Overall, switching from KDPI to ADI changed predicted 5-year graft survival by more than 5% for 14.3% of adolescent donor kidneys and by more than 10% for 1.4% of adolescent donor kidneys (see Figure 3D). The NRI for switching from ADI to KDPI was 0.073 ($p < 0.001$).

Cross-validation testing for ADI revealed a good model fit in all five validation datasets (p -values of 0.15, 0.19, 0.2, 0.21, 0.25) by the Hosmer-Lemeshow goodness-of-fit test. See Figure S8 for an example performance nomogram.

Discussion

Our results about graft survival of pediatric donor kidneys are consistent with other studies, (5–8,14,15) and show that KDPI takes an oversimplified approach to a complex donor population. There are several reasons why KDPI is not a good predictor of graft performance for kidneys from pediatric donors. First, although we began with the same initial variables for the Cox regressions for both child and adolescent donors, we found different covariates significant for each age group. Our decision to create two separate models is supported by the fact that the factors that predict risk are different for each group.

Second, only a few model covariates in the KDPI significantly impact pediatric donor kidney graft survival. The other covariates either do not routinely apply to pediatric donors or have no significant predictive power. In addition, we identified several model covariates that are absent from KDPI but are significantly associated with graft survival in the Cox multivariate analysis (see Tables 2 and 4). For example, although Rao and colleagues (1) found en bloc to be significant in their original Cox regression, and others have also shown en bloc versus SKT as an important predictor for graft performance, (5,7,14,15) it was decided not to include this criterion in KDPI because it is not a donor characteristic per se and is subject to surgeon/center practice pattern variation. However, en bloc is a donor graft characteristic that can be known prior to transplantation. For kidneys from child donors, CDI could be calculated for either en bloc or SKT allocation and both results could be made

available at the time of organ offers. How different surgeons choose to use the data or what donor size cut-offs various OPOs, transplant programs, or individual surgeons employ for determining whether kidneys from small pediatric donors are offered/accepted as individual or en bloc grafts does not change the observed outcome data. In a similar fashion, not all surgeons or transplant programs choose to use very high KDPI adult kidneys, and the survival data of these very high KDPI kidneys are based only on the subset of surgeons/programs who choose to employ them for the intended recipients they select.

Finally, the three donor size variables (age, weight, and height) clearly play an important role in predicting graft performance. Because all pediatric donors are less than 18 and most are less than 80 kg in weight, the KDRI formula when applied to pediatric donors effectively reduces the modeling of the continuous covariates to simple linear parameterization, which means each unit increase in age, weight or height is assumed to lead to logarithmic response in the hazard. The use of categorical covariates for donor age and size better predicted graft performance than using continuous covariates, likely because each change in age, weight, or height does not lead to a proportional scaling of the hazard. The observation that kidneys from donors under the age of 1 year have uniquely worse performance than other small and young donor kidneys highlights the problem with using simple linear parameterizations of continuous covariates for donor size in the pediatric population (see Figure S1). For adolescent donors, a categorical height covariate (see Figure S3) and BMI percentile (gender- and age-adjusted) covariate improved prediction of graft performance over the simple linear parameterization of height and near-linear parameterization of weight found in KDRI.

Our comparisons between models show a significant number of kidneys from pediatric donors are misclassified, more dramatically for child than adolescent donor kidneys. Using the current KDPI index, only 5% of all child donor kidneys were classified as KDPI-A or -B whereas 35.9% of the child donor kidneys would be classified as CDI-A or -B (Table 3). The mostly positive changes in predicted graft survival of individual kidneys using CDI compared to KDPI (see Figure 2D) is consistent with our finding that KDPI leads to a substantial underestimation of the quality of child donor kidneys. In contrast, implementing ADI would not lead to a substantial shifting of the total number of adolescent donors in each sequence, but does sort the adolescent donors into A, B, and C groupings with clinically significant differences in survival, which is not the case for KDPI (see Table 5). The significant NRI for switching to CDI or ADI confirms that there was net improvement with these reclassifications.

Due to the categorical nature of the variables that make up CDI and ADI, our indices are only capable of making large, discreet distinctions between groups of kidneys (see Figure S7 and S8) which is useful at the aggregate population level (i.e., reclassifying pediatric kidneys into appropriate A, B, C, and D groups), but does not unambiguously distinguish between any two particular kidneys in the context of a kidney offer. However, Gupta and colleagues contend that KDPI was not intended for that purpose either: “KDPI was meant to rank order the quality of kidneys as defined by an aggregate population relative risk. It was never meant to be utilized as a discriminatory tool to determine acceptance/rejection of a particular kidney offer.”(8)

Our study has several important limitations. First and foremost, we did not set out to create the definitive model for pediatric donors, but simply to highlight the poor performance of KDPI in this donor population. Attempts should be made to develop models with even better discriminatory power than CDI and ADI using different covariate modeling, different age splits, or different statistical methods. Second, we are not questioning either the OPTN A, B, C, and D group sizes or sequence structure, nor who gets priority for grafts in each sequence. (11) Rather we have used the categories created by the OPTN Kidney committee to show how the KDPI-based allocation model inaccurately classifies pediatric deceased donor kidneys, especially from child donor and therefore misallocates these kidneys based on its own allocation scheme. Third, to mirror the KDPI development process, our analyses are restricted to transplants into adult recipients. Whether or not graft performance will have the same relationship to donor characteristics in pediatric recipients needs further evaluation for both KDPI and CDI/ADI. Although the number of pediatric donor kidneys transplanted into pediatric recipients is too small to statistically evaluate, CDI distinguishes statistically among outcomes of pediatric donor kidneys in adult recipients whereas KDPI does not. Fourth, like KDPI, CDI and ADI are based on SRTR retrospective datasets and have been cross-validated but not prospectively validated with an external dataset.

In sum, we have shown that KDPI is a poor predictive model for pediatric donor kidney transplants and that better predictive models than KDPI can be generated for pediatric kidneys to achieve the efficiency goals set out by the OPTN. Our algorithms can serve as a starting point, but further analysis and discussion are necessary to identify what factors belong in a national donor quality score that would more accurately represent pediatric donor kidney survival.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations Page

ADI	Adolescent Donor Index
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CDI	Child Donor Index
CI	Confidence interval
Cr	Creatinine

CrCl	Creatinine clearance
CVA	Cerebrovascular accident
DCD	Donation after Circulatory Death
EPTS	Estimated post-transplant survival
HR	Hazard ratio
GFR	Glomerular filtration rate
KDPI	Kidney Donor Profile Index
KDRI	Kidney Donor Risk Index
NRI	Net Reclassification Improvement
OPO	Organ Procurement Organization
OPTN	Organ Procurement and Transplantation Network
SKT	Single kidney transplantation
SRTR	Scientific Registry of Transplant Recipients
STAR	Standard Transplant Analysis and Research

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Figure 1.

Figure 2.

Figure 3.

Table 1

New Kidney Allocation System

Sequence A KDPI 20%	Sequence B KDPI > 20% but < 35%	Sequence C KDPI 35% but 85%	Sequence D KDPI > 85%
Highly Sensitized 0-ABDRmm (top 20% EPTS) Prior Living Donor Local Pediatrics Local top 20% EPTS 0-ABDRmm (all) Local (all) Regional pediatrics Regional (top 20%) Regional (all) National Pediatrics National (top 20%) National (all)	Highly Sensitized 0-ABDRmm Prior Living Donor Local pediatrics Local adults Regional pediatrics Regional adults National pediatrics National adults	Highly Sensitized 0-ABDRmm Prior Living Donor Local Regional National	Highly Sensitized 0-ABDRmm Local +Regional National <i>* all categories in sequence D are limited to adult candidates</i>

Reprinted with minor modifications from The Kidney Transplantation Committee. Proposal to Substantially Revise The National Kidney Allocation System. On the web at: http://optn.transplant.hrsa.gov/PublicComment/pubcommentPropSub_311.pdf at p. 6. Last accessed October 11, 2015.

Allocation between candidates with equal priority is determined by dialysis time and ABO match (with additional priority to blood type B candidates).

Abbreviations: ABDR-mm: Zero Antigen mismatch; EPTS: Estimated Post Transplant Survival; and KDPI: Kidney Donor Profile Index

Table 2

Child Donor Index Model Terms and Coefficients

Model term		Adjusted HR	95% CI		P-value
Age	<1	1.838	1.446	2.335	<0.001
	1–4	1.23	1.056	1.432	0.008
Light For Age (<25 th percentile per CDC gender-adjusted weight-for-age growth chart)		1.141	0.983	1.325	0.082
History of Diabetes		2.07	1.141	3.755	0.017
En Bloc		0.661	0.56	0.781	<0.001
Seizure as Mechanism of Death		1.527	1.072	2.177	0.019
Pulmonary Infection in Donor		0.764	0.65	0.898	0.001

Abbreviations: CDC: Center for Disease Control and Prevention; CI = confidence interval; HR = hazard ratio

Table 3

A summary of child donor group size and graft survivals with CDI and KDPI

Classification	KDPI	CDI	Reference
A	92.3 [0.4]	80.0 [15.6]	79.0
B	75.4 [4.6]	77.0 [20.4]	76.9
C	73.7 [84.8]	71.7 [60.9]	70.2
D	70.2 [10.1]	55.2 [3.1]	56.5

5 –year Survival % and [% donors in sequence] for KDPI and CDI. This table displays the mean Kaplan Meier estimated 5-year survival for each A/B/C/D group as classified by KDPI or CDI as well as the size of each group in brackets. E.g. KDPI B contains 4.6% of child donors and had a 5-year survival of 75.4%. The Reference column contains the mean 5-year survival of all donors (adult and pediatric) by KDPI classified A/B/C/D group. A well performing model would have 5 year survivals for each group that match the Reference column survivals. By the binomial test with a 95% confidence level, there was no significant difference between CDI classified group survival and the reference survival. For KDPI, there was a significant difference for all groups except group B.

Table 4

Adolescent Donor Index Model Terms and Coefficients

Model term	Adjusted HR	95% CI		P-value
Donor Height> 180 cm	0.769	0.662	0.892	0.001
DCD or non-heart beating donor	1.255	1.051	1.5	0.012
African American Ethnicity	1.362	1.187	1.562	<0.001
History of Diabetes	1.511	1.008	2.263	0.046
BMI 50–95% (age and gender adjusted per CDC growth chart)	0.855	0.768	0.951	0.004
Suicide as circumstance of donor death	0.822	0.689	0.982	0.03

Abbreviations: BMI: Body Mass Index; CDC: Center for Disease Control and Prevention; CI = confidence interval; DCD: Donation after Circulatory Death

Table 5

A summary of adolescent donor group size and graft survivals with ADI and KDPI

Classification	KDPI	ADI	Reference
A	78.3 [61.5]	80.1 [53.7]	79.0
B	76.6 [25.3]	75.4 [27.5]	76.9
C	72.9 [13]	71.4 [18.1]	70.2
D	70.2 [0.2]	64.6 [0.6]	56.5

5 –year Survival % and [% donors in sequence] for KDPI and ADI. This table displays the mean Kaplan Meier estimated 5-year survival for each A/B/C/D group as classified by KDPI or ADI as well as the size of each group in brackets. E.g. KDPI B contains 25.3% of adolescent donors and had a 5-year survival of 76.6%. The Reference column contains the mean 5-year survival of all donors (adult and pediatric) by KDPI classified A/B/C/D group. A well performing model would have 5 year survivals for each group that match the Reference column survivals. By the binomial test with a 95% confidence level, there was no significant difference between ADI classified group survival and the reference survival. For KDPI, there was a significant difference in survival for group C, but other groups had no significant differences in survival.