CANADIAN COUNCIL FOR DONATION AND TRANSPLANTATION

CONSEIL CANADIEN POUR LE DON ET LA TRANSPLANTATION

Donor and Recipient Age and the Allocation of Deceased Donor Kidneys for Transplantation

July 26, 2006

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A paper prepared for the Canadian Council for Donation and Transplantation

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July 26, 2006

Introduction

The most pressing problem facing kidney transplantation today is the donor organ shortage. Since mortality is reduced by transplantation, death on the waitlist can be viewed as a direct consequence of the shortage of kidney donors. Socioeconomic and ethnic inequities in the allocation of kidneys for transplantation are also unfortunate consequences of the growing donor organ shortage. Many transplant programs have addressed the donor shortage by increasing the use of living donors. However, another strategy has been to expand the criteria for accepting deceased donor kidneys for transplantation.

Older donor age is a common reason for refusing to use a deceased donor kidney, and the pressure to find additional kidneys has led to recent efforts to find ways that older deceased donor kidneys can be used to help meet the demand for transplantation. It has been argued that the deceased donor pool should be expanded by allocating older donor kidneys to older recipients, because the shorter expected graft survival of older kidneys may be less onerous for older recipients, who are not expected to live as long as a younger recipients. Since survival of transplant recipients of all ages is greater than the survival of patients on dialysis, it is argued that it is better to use older deceased donor kidneys than to let their potential recipients continue to remain on dialysis. However, programs that mandate the allocation of older kidneys to older recipients face the challenge of proving that the premises of this practice are correct and that it is therefore ethically justifiable. Voluntary programs that preferentially allocate older kidneys to older recipients must face the challenge of providing informed consent.

Rationale for Age Matching in Kidney Allocation

Older Deceased Donor Kidneys Are Associated with Poorer Outcomes

A number of analyses have demonstrated that older donor age is an important predictor of short- and long-term outcomes after kidney transplantation. After adjusting for recipient age and other risk factors, donors age 50-64 years, and especially donors 65 years and older, have a greater risk of graft failure than younger donors (Table 1). Not surprisingly, this risk is due, in part, to a higher risk of death-censored graft failure (Table 2). However, it is important to note that older donor age is also an independent risk factor for death with function (Table 3). Presumably, the higher mortality associated with older donors is due to poor graft function and/or the use of additional immunosuppressive medication to treat and prevent rejection.

Even Very Old Patients Benefit from Kidney Transplantation

The seminal study by Wolff and colleagues compared survival of recipients of deceased donor kidney transplants with patients remaining placed on the waitlist 1991-1997.[1] Not only did they demonstrate that transplant recipients had a survival advantage, but that the relative survival benefit of transplantation versus remaining on the waitlist was similar for every subgroup examined, including recipients 60-74 years old. Indeed, the adjusted relative risk (compared to the waitlist) for recipients 60-74 years old was 0.37 (95% confidence interval 0.30-0.46, $P < 0.001$) if not diabetic and 0.46 (0.34-0.61, $P < 0.001$) if diabetic.[1]

In a more recent study, Macrae and coworkers examined the survival benefit of transplantation for patients ≥ 75 years of age.[2] In this study, all patients ≥ 75 years old who received a kidney transplant from 1994 to 2000 were compared to those remaining on the transplant waitlist. They found that 5-year patient survival after kidney transplantation was 59.9% for recipients of living donor transplants, 40.3% for recipients of deceased donor kidney transplants, and only 29.7% for dialysis patients on the waitlist. The authors concluded that even after the age of 75 years, kidney transplantation provides substantial life prolongation.

Although comparing transplantation to the waitlist is the most fair comparison to make between transplantation and dialysis, the waitlist is nevertheless an imperfect control group. The assumption is made that patients on the deceased donor waitlist are indeed suitable candidates for transplantation. However, waitlists are not generally audited and there may be a substantial number of patients on the waitlist who are no longer transplant candidates. These patients and/or their physicians will turn down a transplant offer, if one is made. Nevertheless, the difference in survival between transplant recipients and the waitlist is so great that it is unlikely to be entirely an artifact of poor waitlist management.

Older Deceased Donor Kidneys Do Not Function Better in Older Recipients

It has been suggested, that graft survival might be better if older donor kidneys were transplanted into older recipients, rather than into younger recipients. However, the results of registry analyses have failed to support this hypothesis.

Kasiske and Snyder examined the matching of donor and recipient age among 74,297 first deceased donor kidney transplants in 1988-98, using data from the United States Renal Data System.[3] Giving older kidneys to older recipients was common. Recipients ≥ 55 years old received donor kidneys that were ≥ 55 years old 46.2% more often than expected, and they received kidneys that were 18-29 years old 33.6% less often than expected ($P < 0.0001$). Both recipient and donor age were associated with graft survival (determined by death, return to dialysis, or retransplantation). Compared with recipients 18-29 years old, recipients ≥ 55 years old were 25% (95% confidence interval, 15-35%, $P < 0.0001$) more likely to have graft failure. On the other hand, donor kidneys ≥ 55 years old were 78% (95% confidence interval, 58-99%, $P < 0.0001$) more likely to fail compared with kidneys 18-29 years old. However, giving older kidneys to older recipients had little additional effect on graft survival, once the effects of recipient and donor age were taken into account. For example, transplanting donor kidneys ≥ 55 years old into recipients ≥ 55 years old reduced the risk of graft failure only 6% (95% confidence interval, -18 to 8%, $P = 0.3923$) after the effects of donor and recipient age *per se* were taken into account. [3]

In a study of Meier-Kriesche and colleagues, the effects of donor and recipient age on chronic allograft failure were analyzed in 40,289 primary, solitary, Caucasian, adult renal transplants in 1988-1997 using United States Renal Data System data.[4] Chronic allograft failure was defined as allograft loss > 6 months after transplantation, censored for death, recurrent disease, acute rejection, thrombosis, noncompliance, infection, or technical problems. In Cox proportional hazards analysis, the effects of donor and recipient age were qualitatively additive. That is to say, the relative risk of donor age >55 years old was 2.1, while the relative risk of recipient age > 65 years old was 1.9. Hence, in this Cox proportional hazards model a recipient > 65 years old receiving a donor kidney > 55 years old would have a risk of chronic allograft failure that was 2.1+1.9 = 4.0. In a separate Cox

analysis the category of recipient > 65 years old and donor kidney >5 5 years old yielded a relative risk of 3.6; i.e., very similar to the expected additive effects of donor and recipient age.[4]

Keith and coworkers examined outcomes for 50,320 patients who underwent a first deceased donor kidney transplantation in 1990-1997.[5] Patient survival was affected by donor age for all recipient age groups, including recipients older than 55 years. For recipients 0-40 years old, 10-year patient survival for donors 0-17 was 84% compared to 76% for donors ≥ 55 years old; i.e., a difference of 8%. For recipients ≥ 55 years old, 10-year patient survival for donors 0-17 was 48% compared to 35% for donors ≥ 55 years old; i.e., a difference of 13%. Based on this, it appeared that the effects of donor age were similar for young and old recipients, and that donor-recipient age matching would improve survival in younger recipients, but adversely affect survival in older patients by reducing the availability of younger donor kidneys for this group. The authors concluded that "The issue of donor-recipient age matching needs to be debated among the public and transplantation community so that a logical and just system can be developed."

In summary, registry analyses have consistently shown that old donor kidneys are equally bad for young and old recipients, and vice versa. Notwithstanding this biological condition, society may still decide for social reasons that the best (younger) kidneys should go to younger recipients. In a recent editorial Meier-Kriesche and coworkers speculated that if this had been done in the US between 1990-2002, a total of 27,500 graft years and 1.5 billion dollars might have been saved.[6] However, their analysis was based on unadjusted (Kaplan-Meier), projected outcomes assuming that organs were distributed by age-matching, and that nothing else was altered. Whether these benefits would in fact accrue if the allocation scheme were altered is unknown.

Interaction of Older Donor Age and Cold Ischemia Time on Graft Survival

Cold ischemia time (CIT) is associated with an increased risk of graft failure. However, the adverse effects of CIT on graft survival may be limited to recipients of older donors. For example, Woo, and coworkers, performed an analysis of 32,557 recipients of deceased donor kidney transplants between 1996-2000 using United States Renal Data System data.[7] In Cox proportional hazards analysis, CIT had no independent effect on graft failure among recipients of deceased donor kidneys < 55 years old (RR = 0.93, 95% confidence interval 0.84-1.03). However, for recipients of donors ≥ 55 years old, CIT was associated with a 20% increased risk of graft failure (RR=1.20, 95% confidence interval 1.01-1.43).[7] Similarly, in a single center study of 788 first deceased donor transplants, 5-year graft survival was 91% for young and old donors if CIT ≤ 20 hours, 74.3% for CIT > 20 hours and donor < 55 years old, and only 58% if the CIT was > 20 hours and the donor was ≥ 55 years old.[8]

Studies suggesting that adverse effects of CIT on graft survival may be worse in recipients of older donor kidneys may have important implications for organ allocation schemes. It is possible that efforts to limit CIT for older kidneys will be rewarded by improved graft survival. This was a key assumption of both the Eurotransplant Senior Program (ESP) and the Expanded Criteria Donor (ECD) Program in Europe and the US, respectively.

Age Matching in Current Allocation Schemes

The Eurotransplant Senior Program

The ESP was established by Eurotransplant in 1999 to increase the number of deceased donor kidneys that were used, and at the same time to reduce the waiting times of older recipients.[9] The rationale was that older recipients could still benefit from older donor kidneys (≥ 65 years old) that may be less suitable for younger recipients; older kidneys that were not being allocated as part of the standard Eurotransplant Kidney Allocation System (ETKAS) could be suitable for older recipients. The disadvantage to using an older donor could be at least partially offset by mandating that these kidneys be transplanted locally to reduce CIT. In addition, to reduce the immunological risk associated with using older kidneys, access to the ESP was restricted to first kidney transplants only and to patients with a panel reactive antibody (PRA) < 5%.[9]

Data on the results of the ESP are limited to short follow-up. In 1999, the first year of ESP, 227 kidneys were allocated under the ESP and 1-year outcomes were compared to outcomes for 102 control kidneys also ≥ 65 years old allocated under the standard ETKAS.[9] As expected, CIT was less for ESP kidneys versus ETKAS kidneys (medians 12 versus 19 hr). In the ETKAS group, 16 (16%) had PRA > 5% (0% for ESP kidneys), and the median number of HLA mismatches was 2 in ETKAS compared to 4 in the ESP group. Delayed graft function was seen in 33% and 37% of the ESP and ETKAS kidneys, respectively. The 1-year patient and graft survival were not different between the groups.[9] Centers participating in ESP reported 2-fold more donors that were ≥ 65 years old compared to non-ESP centers (14% v. 7%, respectively). The median waiting time between first dialysis and transplantation for patients ≥ 65 years old decreased from 943 days in 1998 to 707 days in 1999. Waiting times for younger patients increased during this same time. Thus, it appeared that the ESP program was successful in reducing the waiting times of older recipients.[9]

Since this report, there have been other reports from individual centers participating in the ESP. Fritshe, and coworkers, compared 69 ESP transplants to 71 ETKAS transplant recipients ≥6 0 years old.[10] The ESP patients were older (67.9 ± 2.5 v. 63.9 ± 2.9 years), had older donors (71.2 ± 3.9 v. 44.6 ± 14.5 years), more HLA mismatches (4.2 ± 1.2 v. 1.6 ± 1.7), but shorter CIT (7.8 ± 3.4 v. 14.2 ± 5.5 years). The incidence of delayed graft function, as well as patient and graft survival were similar at 1 year, but the incidence of acute rejection was higher in the ESP (43.2%) v. ETKAS (27.4%) groups. During the period of observation the use of older donor rose from < 2% to 11%, and the use of older recipients increased from < 2% to 16%.[10]

Fabrizi, and coworkers, compared 59 patients who received an older donor kidney under ESP in 1999-2003 with 44 patients ≥ 65 years old who received a younger donor through the ETKAS.[11] Donor age was higher (69 v. 36 years; $P < 0.001$) and CIT shorter in ESP v. ETKAS groups (10 v. 15 hr; $P < 0.001$). The number of HLA mismatches was greater in ESP v. ETKAS groups (3.8 v. 3.0; $P = 0.003$). Primary nonfunction, delayed graft function, patient survival, graft survival, and the rates of acute rejection were not different between the 2 groups, but serum creatinine at discharge was higher ESP v. ETKAS patients (1.7 vs. 1.4 mg/dL; $P < 0.001$).[11]

In summary, the early experience of the ESP appears to indicate that the allocation of donor kidneys ≥ 65 years old to older recipients results in a higher utilization of older kidneys, more older

recipients receiving transplants, and a reduction in waiting times for older recipients. How much the shorter waiting times and reduction in CIT from the ESP will offset the expected adverse long-term consequences of using older kidneys can only be determined with analyses of long-term follow-up data, using appropriate controls and adjustment for confounding variables. Similarly, which older patients benefit from accepting older donor kidneys, and which would be better served by remaining on the ETKAS waitlist remains to be determined. Of course, the ESP could be used as a method to ration kidneys to older patients (giving preference to younger patients), even if they might do better on the ETKAS waitlist.

The US Expanded Criteria Donor Program

In November 2002, the US Organ Procurement and Transplantation Network (OPTN) implemented a program establishing a second, separate, voluntary, waitlist to allocate expanded criteria donor (ECD) kidneys by waiting time alone. The purposes of the ECD program were to reduce CIT by more quickly allocating kidneys that otherwise were frequently turned down by centers under the usual allocation program, and to increase the use of ECD kidneys. The ECD kidneys for this program were determined to have a risk of graft failure ≥ 1.7 times that of ideal donors, and included donors ≥ 60 years old and donors 50 to 59 years old with at least 2 of the following: terminal creatinine > 1.5 mg/dL, history of hypertension, or death by cerebrovascular accident.

An analysis of the first 18 months of the ECD program compared results to the 18 months immediately preceding the ECD program.[12] There was a 15.0% increase in ECD kidney transplants between the 2 time periods. The ECD kidneys made up 16.8% of transplants, compared with 14.5% ($P < 0.001$), in the prior period. The discard rate was unchanged. The predicted (based on prior analyses of OPTN data) median relative risk for graft failure for transplanted ECD kidneys was 2.07 compared to 1.99 in the prepolicy period ($P=0.13$). The percentage of transplanted ECD kidneys with CIT < 12 hours increased, and the corresponding percentage for CIT ≥ 24 hours declined.[12] Thus, it appeared that the ECD program was associated with an increase in ECD kidney recoveries and transplants.

The long-term results of the ECD program will only become clear after several years of follow-up. However, it is possible to examine the effects of ECD kidneys (using the same definition) with OPTN data collected prior to starting the ECD program. In a recent analysis, recipients of ECD kidneys had improved survival compared to patients on the waitlist.[13] However, patient survival was 5% lower at 1 year and 8-12% lower at 3-5 years for ECD kidney recipients compared to recipients of non-ECD kidneys. Adjusted graft survival of ECD kidneys as 8% lower at 1 year and 15-20% lower at 3-5 years after transplantation compared to non-ECD kidneys. Some patients, e.g. those < 40 years of age, African Americans, and Asians for whom the median waiting time is less than 1350 days received no survival benefit from ECD kidney transplantation. [13]

Another study compared mortality after ECD kidney transplantation with a control group made up of non-ECD recipients and those still on the waitlist.[14] The study included 109,127 patients added to the waitlist between 1/1/95 and 12/31/02, and followed through 7/31/04. Almost none of these patients were part of the ECD allocation program that first started in 11/1/02. There were 7790 ECD kidney transplants. Because there was increased recipient mortality for ECD transplants in the perioperative period, patient survival did not equal that of controls until 3.5 years posttransplant.

Long-term relative mortality risk was 17% lower for ECD recipients compared to controls (RR = 0.83; 95% confidence interval, 0.77-0.90; P < .001). Subgroups with significant ECD survival benefit included patients > 40 years old, non-Hispanics, unsensitized patients, and those with diabetes or hypertension. In areas with long median waiting times (>1350 days), ECD recipients had a 27% lower risk of death (RR = 0.73; 95% confidence interval, 0.64-0.83; P < .001). In areas with shorter waiting times, only recipients with diabetes had a survival benefit from an ECD kidney. The authors concluded that ECD kidney transplants should be offered principally to candidates older than 40 years in OPOs with long waiting times. In OPOs with shorter waiting times, in which non-ECD kidney transplant availability is higher, candidates should be counseled that ECD survival benefit is observed only for patients with diabetes.[14]

In summary, early results from the ECD allocation program indicate an increase in ECD kidney recoveries and transplants. However, analyses of historical data (prior to the establishment of the ECD program) indicate that not all patients will have a survival benefit from accepting an ECD kidney compared to waiting for a kidney allocated under the standard OPTN allocation system. Thus, the ethics of informed consent mean that caregivers must make some sophisticated calculations in order to determine if placement on the ECD list will benefit individual patients.

Other Approaches for Using Older Deceased Donor Kidneys

Can Histology Help to Determine which Older Kidneys to Transplant?

The usefulness of histological assessment of deceased donor kidneys in predicting outcomes after transplantation has been controversial. In a study of Howie and coworkers wedge biopsies were obtained 30 minutes after transplantation of 500 deceased donor kidneys.[15] The sample was enriched by including 50 biopsies selected to have an increased amount of histological damage. The amount of chronic damage was assessed using an interactive image analysis system, and was scored as a percent of cortical area. An index of 0% (n=242) was associated with better graft survival than 1%, but there was little difference between 1% and 39% (n=249). An index of 40% or more (n=9) was associated with the worst survival. However, after controlling for donor age, only a chronic damage score ≥ 40% was independently associated with a worse outcome. Thus, even morphometric assessment of histological damage did not add much to donor age in predicting long-term graft survival.[15] However, this study included only transplanted kidneys, and could not assess the utility of histology in determining the suitability of kidneys that were discarded.

There are practical barriers to using histology to allocate deceased donor kidneys. Obtaining tissue before harvesting organs is generally not feasible. Transporting kidney tissue to an experienced renal pathologist, performing appropriate stains and interpreting the results could delay the allocation of kidneys (and increase CIT), if the information were to be included in an allocation scheme. Finally, there are few studies to show that the information would be useful in predicting outcomes.

Two for One

It has been suggested that 2 (rather than 1) older donor kidneys, which would otherwise be discarded, could be successfully transplanted. This practice is currently uncommon, and there are few data on selection criteria and outcomes. Alfrey, et al., reported on 287 patients in a regional dual

kidney registry who underwent dual kidney transplantations.[16] Mean donor age was 58 ± 13 years and the mean number of globally sclerotic glomeruli on procurement biopsy was 16+/-13%. The incidence of DGF was 27%. Mean CIT was 29 ± 10 v. 22 ± 9 hr in recipients with and without DGF, respectively ($P < 0.001$). The 1- and 5-year graft survival rates were significantly worse in recipients with DGF (79% and 54%) than in recipients without DGF (90% and 74%).[16]

Remuzzi, and coworkers, used preimplantation biopsies to allocate 1 or 2 deceased donor kidneys from donors older than 60 years to recipients who were > 50 years old and no more than 10 years older or younger than their corresponding donors.[17] Kidneys were scored on a scale of 0 to 12 based on chronic histologic changes. Kidneys with a score of 0-3 were considered for use as a single kidney. Kidneys with a score 4-6 were transplanted as dual kidneys, and kidneys scored ≥7 were discarded. Of 62 kidneys transplanted in this manner, 54 (87%) were dual kidney transplants and only 8 were single kidney transplants. Outcomes of these 62 transplants were compared to those of 124 donors > 60 years old, transplanted as single kidneys without histology, and another 124 ≤ 60 years old. Outcomes for the biopsy-allocated single or dual kidney transplants were similar to those for donors ≤ 60 years old and superior to those for donors > 60 years old that were allocated as single kidneys without biopsy. The authors concluded that histologic evaluation of donors 60 years old used to determine whether or not to transplant 1 or 2 kidneys was effective in achieving good results for these older donor kidneys. However, they did not indicate how many kidneys were discarded, and the majority of kidneys transplanted were transplanted as 2 kidneys. Thus, it is possible that similar results would have been achieved by transplanting 2 kidneys in every case of donors > age 60, and the role of biopsy remains unclear.[17] In addition, whether overall patient survival (compared to the waitlist) would be better transplanting 1 rather than 2 older kidneys, with or without biopsy guidance, was not addressed in this study.

In summary, when to allocate older kidneys as dual kidney transplants, and whether to use preimplantation biopsies to make this decision is still on open question. A randomized trial is needed to help to resolve this important issue.

Conclusions

The current shortage of organ donors for transplantation has created an impetus to use older donor kidneys that were formerly considered unsuitable for transplantation. A popular approach is to use older deceased donor kidneys for older recipients, reasoning that the shorter graft survival of older kidneys may be less of a problem for older recipients, who have a shorter life expectancy. However, studies suggest that older donor kidneys are just as onerous for older recipients as they are for younger recipients. Therefore, the decision to allocate older kidneys preferentially to older recipients must either be voluntary and/or done for the public good.

If the preferential allocation of older kidneys to older recipients is voluntary, then it should be done with informed consent. If a recipient (young or old) is given the opportunity to accept an older kidney, because it may be better than the alternative, then that potential recipient should be provided with the best available information on the chances of survival with our without accepting the offer of an older deceased donor kidney. Alternatively, Society can take the responsibility for making such decisions in a mandatory deceased donor kidney allocation scheme. In this case, the ethical responsibility and burden of proof shifts to a Society that must determine the appropriate balance between the rights of individuals and the common good.

Tables

Table 1. Effects of recipient and donor age on graft failure after deceased donor kidney transplantations in 1998-2003 (N=42,979).

Characteristic	Percent of Population	Relative Risk (95% C.I.)	P-Value
Recipient age (years)			
0-17	3.7	1.27 (1.11-1.46)	0.0006
18-34 (reference)	13.7	1.00 (----------)	---------
35-49	30.8	0.87 (0.81-0.94)	0.0001
50-64	39.7	1.05 (0.98-1.13)	0.1334
≥ 65	12.1	1.42 (1.31-1.55)	<0.0001
Donor age (years)			
0-17	14.7	1.03 (0.95-1.12)	0.4507
18-34 (reference)	25.7	1.00 (----------)	---------
35-49	26.0	1.18 (1.11-1.26)	< 0.0001
50-64	20.5	1.43 (1.32-1.55)	< 0.0001
≥ 65	3.8	1.78 (1.57-2.01)	< 0.0001
Unknown	9.4	1.44 (1.14-1.82)	0.0020

Adjusted for transplant era, recipient gender, recipient race, recipient ethnicity, primary cause of end-stage renal disease, pre-transplant hepatitis B & C serologies, education level, employment status, primary payor, prior time on dialysis, donor gender, donor race, donor ethnicity, and donor cause of death.

Abbreviations: C.I., confidence interval.

Data are from the U.S. Renal Data System, USRDS 2005 Annual Data Report: Atlas of End-Stage Renal Disease in the United States, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2005.

Table 2. Effects of recipient and donor age on return to dialysis or preemptive re-transplantation after deceased donor kidney transplantations in 1998-2003 (N=42,979).

Characteristic	Percent of Population	Relative Risk (95% C.I.)	P-Value
Recipient age (years)			
0-17	3.7	1.37 (1.18-1.60)	< 0.0001
18-34 (reference)	13.7	1.00 (----------)	---------
35-49	30.8	0.70 (0.65-0.76)	< 0.0001
50-64	39.7	0.57 (0.53-0.63)	< 0.0001
≥ 65	12.1	0.58 (1.52-0.65)	< 0.0001
Donor age (years)			
0-17	14.7	1.11 (1.00-1.23)	0.0508
18-34 (reference)	25.7	1.00 (----------)	---------
35-49	26.0	1.21 (1.10-1.32)	< 0.0001
50-64	20.5	1.48 (1.32-1.65)	< 0.0001
≥ 65	3.8	1.98 (1.68-2.35)	< 0.0001
Unknown	9.4	1.38 (1.02-1.86)	0.0379

Adjusted for transplant era, recipient gender, recipient race, recipient ethnicity, primary cause of end-stage renal disease, pre-transplant hepatitis B & C serologies, education level, employment status, primary payor, prior time on dialysis, donor gender, donor race, donor ethnicity, and donor cause of death.

Abbreviations: C.I., confidence interval.

Data are from the U.S. Renal Data System, USRDS 2005 Annual Data Report: Atlas of End-Stage Renal Disease in the United States, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2005.

Table 3. Effects of recipient and donor age on death after deceased donor kidney transplantations in 1998-2003 (N=42,979).

Characteristic	Percent of Population	Relative Risk (95% C.I.)	P-Value
Recipient age (years)			
0-17	3.7	1.06 (0.75-1.51)	0.7272
18-34 (reference)	13.7	1.00 (----------)	---------
35-49	30.8	1.90 (1.62-2.24)	< 0.0001
50-64	39.7	3.72 (3.18-4.35)	< 0.0001
≥ 65	12.1	6.21 (5.26-7.83)	< 0.0001
Donor age (years)			
0-17	14.7	0.93 (0.83-1.05)	0.2685
18-34 (reference)	25.7	1.00 (----------)	---------
35-49	26.0	1.16 (1.05-1.27)	0.0029
50-64	20.5	1.37 (1.22-1.54)	< 0.0001
≥ 65	3.8	1.62 (1.34-1.95)	< 0.0001
Unknown	9.4	1.56 (1.09-2.24)	0.0160

Adjusted for transplant era, recipient gender, recipient race, recipient ethnicity, primary cause of end-stage renal disease, pre-transplant hepatitis B & C serologies, education level, employment status, primary payor, prior time on dialysis, donor gender, donor race, donor ethnicity, and donor cause of death.

Abbreviations: C.I., confidence interval.

Data are from the U.S. Renal Data System, USRDS 2005 Annual Data Report: Atlas of End-Stage Renal Disease in the United States, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2005.

References

1. Wolfe RA, Ashby VB, Milford EL, Ojo AO, Ettenger RE, Agodoa LY, Held PJ, Port FK: Comparison of mortality in all patients on dialysis, patients on dialysis awaiting transplantation, and recipients of a first cadaveric transplant. N Engl J Med 341:1725-1730, 1999

2. Macrae J, Friedman AL, Friedman EA, Eggers P: Live and deceased donor kidney transplantation in patients aged 75 years and older in the United States. Int Urol Nephrol 37:641-648, 2005

3. Kasiske BL, Snyder J: Matching older kidneys with older patients does not improve allograft survival. J Am Soc Nephrol 13:1067-1072, 2002

4. Meier-Kriesche HU, Cibrik DM, Ojo AO, Hanson JA, Magee JC, Rudich SM, Leichtman AB, Kaplan B: Interaction between donor and recipient age in determining the risk of chronic renal allograft failure. J Am Geriatr Soc 50:14-17, 2002

5. Keith DS, DeMattos A, Golconda M, Prather J, Norman D: Effect of donor recipient age match on survival after first deceased donor renal transplantation. J Am Soc Nephrol 15:1086-1091, 2004

6. Meier-Kriesche HU, Schold JD, Gaston RS, Wadstrom J, Kaplan B: Kidneys from deceased donors: maximizing the value of a scarce resource. Am J Transplant 5:1725-1730, 2005

7. Woo YM, Gill JS, Johnson N, Pereira BJ, Hariharan S: The advanced age deceased kidney donor: current outcomes and future opportunities. Kidney Int 67:2407-2414, 2005

8. Asderakis A, Dyer P, Augustine T, Worthington J, Campbell B, Johnson RW: Effect of cold ischemic time and HLA matching in kidneys coming from "young" and "old" donors: do not leave for tomorrow what you can do tonight. Transplantation 72:674-678, 2001

9. Smits JM, Persijn GG, van Houwelingen HC, Claas FH, Frei U: Evaluation of the Eurotransplant Senior Program. The results of the first year. Am J Transplant 2:664-670, 2002

10. Fritsche L, Horstrup J, Budde K, Reinke P, Giessing M, Tullius S, Loening S, Neuhaus P, Neumayer HH, Frei U: Old-for-old kidney allocation allows successful expansion of the donor and recipient pool. Am J Transplant 3:1434-1439, 2003

11. Fabrizii V, Kovarik J, Bodingbauer M, Kramar R, Horl WH, Winkelmayer WC: Long-term patient and graft survival in the eurotransplant senior program: a single-center experience. Transplantation 80:582-589, 2005

12. Sung RS, Guidinger MK, Lake CD, McBride MA, Greenstein SM, Delmonico FL, Port FK, Merion RM, Leichtman AB: Impact of the expanded criteria donor allocation system on the use of expanded criteria donor kidneys. Transplantation 79:1257-1261, 2005

13. Ojo AO: Expanded criteria donors: process and outcomes. Semin Dial 18:463-468, 2005

14. Merion RM, Ashby VB, Wolfe RA, Distant DA, Hulbert-Shearon TE, Metzger RA, Ojo AO, Port FK: Deceased-donor characteristics and the survival benefit of kidney transplantation. JAMA 294:2726-2733, 2005

15. Howie AJ, Ferreira MA, Lipkin GW, Adu D: Measurement of chronic damage in the donor kidney and graft survival. Transplantation 77:1058-1065, 2004

16. Alfrey EJ, Boissy AR, Lerner SM: Dual-kidney transplants: long-term results. Transplantation 75:1232-1236, 2003

17. Remuzzi G, Cravedi P, Perna A, Dimitrov BD, Turturro M, Locatelli G, Rigotti P, Baldan N, Beatini M, Valente U, Scalamogna M, Ruggenenti P: Long-term outcome of renal transplantation from older donors. N Engl J Med 354:343-352, 2006