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The Survival Advantage of Pancreas after Kidney Transplantation

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Running Head: Pancreas after kidney survival

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Abbreviations: IPTR: International Pancreas Transplantation Registry JAMA: Journal of the American Medical Association, LDRTx: Living donor renal transplantation, OPTN: Organ Procurement and Transplantation Network PAK: pancreas after kidney transplantation, SPK: simultaneous pancreas and kidney transplantation, SRTR: Scientific Registry of Transplant Recipients, SSDMF: Social security death master file

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Abstract

Patient Survival following Pancreas After Kidney transplantation **(**PAK**)** has been reported to be inferior to patient survival following Simultaneous Pancreas and Kidney transplantation (SPK). This analysis examines national data to further explore allograft (kidney and pancreas) and patient survival after PAK. Kaplan-Meier and Cox proportional Hazard models were used to analyze OPTN data from 1995-2010. The analysis compared PAK and SPK candidates and recipients. Kaplan-Meier analysis demonstrated that PAK following either a living or deceased donor kidney transplant is associated with increased kidney graft survival compared to Type 1 diabetic recipients who only received a kidney. The best kidney allograft survival was for living donor kidney followed by PAK. Living donor kidney was associated with increased pancreas allograft survival compared to deceased donor kidney. PAK transplant recipients who receive both organs have a survival advantage compared to uremic candidates who receive neither (SPK waitlist). Compared to uremic diabetic waitlist patients, SPK and PAK recipients showed similar overall patient survival. Successful PAK offers a survival advantage compared to receiving neither a kidney nor a pancreas transplant. These data also suggest that receiving a pancreas (after kidney) transplant may have a protective effect on the kidney allograft.

Key words: Pancreas transplantation, Pancreas after kidney transplantation, transplant outcomes, survival

Introduction:

Beginning in 2004, there has been a profound decline in the number of pancreas transplants performed in the United States (1, 2). Although several factors may contribute, there is a perception in the pancreas transplant community that this decline, particularly pancreas after kidney transplantation (PAK), occurred immediately following publication of a study funded by the National Institutes of Health in the Journal of the American Medical Association (JAMA) in 2003(3). This study was a retrospective observational study performed as a query to the Organ Procurement and Transplantation Network (OPTN) database comparing survival rates at 1 and 4 years post-transplant and the relative risk of death between patients on the waiting list for a subsequent pancreas following their kidney and pancreas transplant recipients. In that study, the authors concluded that patients receiving solitary pancreas transplants, including PAK, had an increased mortality risk compared to those remaining on the waiting list and receiving conventional medical therapy. Two subsequent rebuttal studies have been published from the International Pancreas Transplantation Registry (IPTR) employing a similar study design and using the same database(4, 5). However, these studies uniquely included supplemental data from the IPTR and accounted for recipients listed more than once, recipients that were not re-categorized after isolated renal transplantation and recipients that were inappropriately excluded. Notably, these studies came to a contradictory conclusion compared to the JAMA report indicating that PAK transplanted recipients did not have increased mortality compared to those waiting for a PAK. Despite these additional analyses and published studies, there remains reticence among physicians to offer PAK transplants due to the possible negative impacts on kidney function and patient

survival. Given the discrepancy of results in the literature, further critical analyses are necessary to correct a possible misapprehension and achieve a more comprehensive view of the overall benefits and risks of PAK transplants.

Pancreas transplantation is frequently considered only a life-enhancing rather than a life-saving procedure. However, abundant evidence indicates that, similar to kidney transplantation, successful pancreas transplantation is clearly life-extending. For example, the University of Wisconsin published their experience with one thousand kidney-pancreas transplantations with 22 year follow-up(6). In this retrospective analysis, patient survival following transplantation of both a kidney and a pancreas was dramatically superior to all other options for type 1 diabetic uremic patients, particularly deceased donor renal transplantation alone and dialysis options. Although not evident for the first 4 to 5 years (beyond the 4 year interval of the prior mentioned publications), with the extended follow-up achieved in this particular study, the long-term patient survival following simultaneous pancreas and kidney transplantation (SPK) is even remarkably superior to that of Type 1 diabetic uremic recipients undergoing living donor renal transplantation (LDRTx) alone, supporting the fact that freedom from diabetes has a clear survival advantage. Furthermore, if a suitable diabetic uremic patient is evaluated for transplantation, they would have historically been offered the choice between an SPK transplant or, if they had a suitable living donor, LDRTx followed by PAK. Since the uremic diabetic state is the actual starting point, the relevant waiting list survival to consider is actually that of a candidate that requires both a kidney and a pancreas: i.e., on the waitlist for an SPK, not the survival of a renal transplant recipient waiting for a pancreas alone as was used in the JAMA publication(3). If such a patient ultimately no

longer required dialysis and were no longer diabetic, then there could be a greater patient survival advantage compared to remaining diabetic but free from renal failure. This study was designed to reproduce the original JAMA study from 2003 adding a waiting list comparison group (PAK transplanted group being compared to waitlisted SPK candidates), while also looking at kidney and pancreas allograft survival and extending the survival analyses to 10 years post-transplant.

Methods:

This study used data from the Organ Procurement and Transplantation Network (OPTN). The OPTN data system includes data on all donor, wait-listed candidates, and transplant recipients in the US, submitted by the members of the OPTN, and has been described elsewhere. The Health Resources and Services Administration (HRSA), U.S. Department of Health and Human Services provides oversight to the activities of the OPTN contractor. The OPTN database was queried for candidates who were registered from January 1st, 1995 to December 31st, 2010 for an SPK transplant or a PAK transplant. The analysis excluded pediatric candidates (age < 18) and recipients who had a multi-organ transplant other than an SPK transplant or a previous transplant other than a kidney. Recipients who received a pancreas and a kidney at the same time from two different donors were also excluded from the analysis. After these exclusions, the cohort consisted of 25,361 patients. Of these patients 19,725 were waiting for an SPK and 12,308 received an SPK. Additionally, 5,636 candidates were waiting for a PAK and 3,358 received a PAK. PAK candidates were defined as receiving a kidney and waiting for a pancreas transplant. An additional cohort consisting of 736 deceased donor and 1275 living donor kidney transplants in recipients with Type 1 diabetes mellitus

performed during the same period were also included for comparison of kidney allograft survival. Pancreas allograft outcomes were determined from graft failures defined by individual centers as reported to UNOS. This analysis did not exclude PAK candidates with a creatinine greater than 2 ng/ml as was the case in the aforementioned study in JAMA (3)because creatinine was not a required field before October 1999. Therefore to reduce bias, it is necessary to include all candidates on the waiting list and transplanted before October 1999, regardless of creatinine values. Social security death master file (SSDMF) supplanted all death data. If transplanted recipients were not reported dead to the OPTN or not located in the SSDMF, then they were considered alive and were censored at 3,650 days. Candidates who were not transplanted were also censored at 3,650 days plus median waiting time to transplant for the anticipated transplant type. The analysis compared outcomes for SPK waiting list candidates to SPK and PAK transplant recipients. Kaplan-Meier log-rank tests were used to test differences in unadjusted waitlist and post-transplant mortality.

The analysis considered the impact of each transplant type: Deceased donor kidney alone, SPK, LDRTx alone, LDRTx followed by a pancreas and deceased donor kidney followed by a pancreas. The impact of each of these transplant types on pancreas and kidney allograft survival and patient survival was assessed. To accurately measure kidney allograft survival, candidates who are waiting for or received a PAK were subdivided into 4 groups by kidney donor type: Deceased donor kidney with or without a pancreas and LDRTx with or without a pancreas. A cox-proportional hazards model was used to determine if receiving a pancreas after a living or a deceased donor transplant impacted kidney allograft survival, while a log-rank test was used to determine if

receiving a LDRTx increased graft survival of the pancreas compared to receiving a deceased donor kidney. A time dependent covariate analysis using cox-proportional hazard model was used to determine survival from listing for each transplant type. The models also allowed piecewise testing of mortality outcomes during 5 specific clinical time periods (0 to 90 days, 91 to 365 days, 1 to 3 years, 3 to 5 years, 5 to 10 years). The modeling followed the transplanted group until death or 10 years post-transplant. Hazard ratios were calculated to compare the risk of mortality within each time period, by comparing the average mortality for waitlisted candidates to the average mortality for transplanted recipients. SPK and PAK analyses were adjusted for year of listing and the PAK analysis for kidney donor type (living or deceased). Statistical analyses were performed using SAS version 9.3 (SAS Institute Inc. Cary, NC) and R 3.3.2.

Results:

Demographic distributions for SPK and PAK waitlisted candidate groups were clinically similar. However, because of the large number of subjects, it is not surprising there were statistical differences in the demographics within each group. Table 1 shows the patient demographics for each group. The median age at listing was 40 for SPK candidates and 42 for PAK candidates. For both groups, most candidates were male and Caucasian. The median time to transplant was 430 days for SPKs and 465 days for PAKs. The median interval from kidney to pancreas transplantation was 657 days and the median time from kidney transplantation until official listing for pancreas transplantation was 297 days.

Waitlist and post-transplant patient survival by transplant procedure type are shown in Figure 1. The 10 year waitlist survival for the SPK waitlist group was dramatically lower than either of the transplanted groups (PAK or SPK). At 10 years, the survival for waitlisted SPK candidates was 26.4%. Post-transplant survival was very similar through 5 years for both groups (82.9% PAK and 86.4% SPK) but diverges thereafter, and at 10 years post-transplant SPK recipients had higher survival than PAK recipients ($p < 0.001$, PAK 63.2 % and SPK 70.3%).

Kidney and pancreas graft survival for both PAK and SPK transplant types are shown in Figure 2. The cox-proportional hazard model comparing kidney donor type (living vs. deceased) and whether PAK candidates received a pancreas shows that receiving a LDRTx was associated with improved kidney graft survival compared to receiving a DDRTx ($p < 0.001$). Furthermore, receiving a subsequent pancreas was also associated with improved long-term kidney graft survival ($p < 0.001$) versus not receiving a subsequent pancreas transplant, regardless of whether the kidney was from a deceased or living donor. However, the interaction between donor type and pancreas transplantation was not significant with respect to kidney graft survival ($p = 0.09$).

In those patients who received a subsequent pancreas transplant, kidney graft survival was superior than those who did not. For example, ten-year kidney graft survival was 69.8% for recipients who received a LDRTx and a pancreas compared to 61.0% for those who only received a LDRTx. Similarly, 10-year kidney graft survival for recipients who received a deceased donor kidney transplant followed by a pancreas was 66.0%, while kidney graft survival for recipients who just received a deceased donor kidney was 50.4%. The kidney graft survival in SPK recipients was 61% at 10 years. The best short-

term and long-term kidney graft survival was seen in patients receiving a LDRTx followed by a PAK transplant. In both cases of PAK transplants, regardless of the type of kidney allografts, kidney graft survival was superior to that of SPK transplants (69.8% and 66.0% vs. 61%, $p < 0.001$).

A Cox proportional hazard model was used to determine if receiving a LDRTx was associated with increased pancreas graft survival compared to recipients of DDRTx. At 10 years, PAK recipients who received a LDRTx had a pancreas graft survival of 44.4% compared to 41.7% for those PAK recipients who received a deceased donor kidney ($p < 0.001$). In comparison, SPK pancreas graft survival was 58.7% at 10 years.

As both PAK and SPK transplants are potential, yet alternative definitive treatments for the same patient population, namely diabetic uremic patients, we sought to compare patient survival of these two transplant types to wait-listed diabetic uremic candidates. Figure 3 shows the hazard ratios for patient survival of SPK and PAK transplant types relative to diabetic uremic patients remaining on the SPK waiting list. Panel one compares SPK recipients to waitlisted (WL) SPK candidates who did not receive a transplant (WL SPK No TX). The second panel compares PAK recipients to waitlisted SPK candidates who did not receive a transplant (WL SPK No TX). This comparison is particularly important because it shows the benefit of receiving a PAK compared to candidates who receive neither a kidney nor a pancreas.

In the SPK analysis, survival at 90 days demonstrated no benefit of transplant compared to staying on the waitlist (HR =1.12, CI = [0.996, 1.25]), which is the case for almost all transplants where in many cases transplantation is even associated with a higher short-term mortality risk. However, beyond the first 90 days, there was highly

significant patient survival benefit associated with receiving an SPK transplant that included time intervals from 90 to 365 days (HR =0.29, CI = [0.25, 0.33]), 1 to 3 years (HR =0.17, CI = [0.15, 0.18]), 3 to 5 years (HR =0.19, CI = [0.17, 0.21]), and which even extended out to 5 to 10 years (HR =0.24, CI = [0.21, 0.28]). Among the 7,417 SPK candidates who did not get a transplant 2,881 died (38.8%); this compared to 12,308 SPK recipients of whom 3,049 died over 10 years (24.8%). When comparing PAK recipients to SPK waitlisted candidates who did not receive a transplant there was also a strong patient survival benefit associated with PAK transplant at each time interval. Specifically, at all time points post-transplant, including up to 90 days (HR= 0.58, CI =[0.45-0.73]), up to one year (90 to 365 days) (HR = 0.22, CI = [0.17-0.27]), from 1 to 3 years (HR= 0.18, CI =[0.15-0.20]), from 3 to 5 years (HR= 0.28, CI =[0.23-0.32]) and from 5 to 10 year (HR= 0.34, CI=[0.28-0.41]) there was an observed benefit associated with PAK transplantation. A total of 953 recipients died after PAK transplants out of 3,358 transplants at 10 years (28.4%) compared to 2,881 SPK candidates out of 7,417 SPK candidates (38.8%) who were waiting for a transplant. Thus, when compared to an SPK waiting list uremic diabetic population, both SPK and PAK have a similar patient survival benefit (Figure 3).

When evaluating the potential benefits of patient survival in PAK transplants, one can alternatively compare post-PAK survival to that of those who received a kidney and are waiting for a pancreas. Doing the analysis in this manner resulted in an estimated hazard of death after surgery in the first 90 days 3.1 times greater than staying on the waitlist(CI [2.3-4.0])(data not shown). Although the hazard ratio for the first 90 days demonstrates that there is an increased risk associated with transplantation, it is important

to note that there were only 13 deaths within 90 days of PAK transplant out of 3,358 PAK transplants. From 90 to 365 days the HR was 1.19 (CI [0.92-1.53]), and from 1 to 3 years the HR fell to 1.0 (CI [0.81-1.23]). Longer term, the HR for death from 3 to 5 years was 1.17 (CI [0.93-1.45]), and from 5 to 10 years the HR was 1.07 (CI [0.84-1.37]). Overall 314 died out of 2,278 while waiting for a pancreas after receiving a kidney transplant (13.7%), compared 953 who died out of the 3,358 post-transplant recipients for PAKs (28.4%).

In summary, PAK transplant recipients who receive both organs have an increased survival advantage compared to uremic candidates who receive neither a pancreas nor a kidney transplant (Figure 3, 2nd panel). Except for the first 90 days post-PAK, PAK recipients experienced similar patient mortality risk to recipients of kidneys who were waiting for a pancreas transplant. Moreover, compared to uremic diabetic waitlisted patients, SPK and PAK recipients showed similar overall patient survival benefits (Figure 3, 1st panel versus 2nd panel).

Discussion

For the Type 1 diabetic uremic transplant candidate, LDRTx followed by PAK transplantation is a very appealing alternative to the more commonly performed SPK transplantation (7-12). The primary advantages of a PAK compared to an SPK stem from the fact that a LDRTx is widely recognized to have superior patient and allograft survival outcomes compared to deceased donor renal transplantation. According to the Scientific Registry of Transplant Recipients and Organ Procurement and Transplantation Network (SRTR/OPTN) 2016 Annual Report, 6 months and 10 year graft survival rates for an LDRTx are significantly better than those of a standard criteria deceased donor kidney

transplant, which is how the renal allograft would likely be classified in the SPK recipient(13). The timing of an LDRTx also supports preemptive renal transplantation prior to the initiation of dialysis, which avoids the potential morbidity and cost of dialysis and may also be associated with an allograft and patient survival advantage (14-17). Moreover, due to choice of the local DSA to allocate two kidneys to two separate kidney recipients when an SPK is not placed locally, there are many isolated pancreas grafts that go untransplanted and are readily available for pancreas transplantation without a kidney. Increased use of these isolated pancreas allografts could result in a significantly reduced waiting time and potentially decreased mortality for the non-sensitized recipient interested in pursuing living donor renal transplantation followed by PAK(4). Finally, if LDRTx followed by PAK were aggressively pursued by most pancreas transplant centers, there would be a significant number of additional standard criteria donor renal allografts available for the deceased donor pool.

There are two major disadvantages to PAK transplantation: the requirement for two separate operations and the separate origin of the renal and pancreatic allografts. In terms of the operations, the concern regarding undergoing two separate operations and courses of anesthesia has not been associated with any increased mortality as patient survival rates and 1 year technical graft failure rates are nearly identical for both SPK and PAK according to the IPTR database (96% patient survival rates and <10% technical graft failure rates for both)(18). Nonetheless, the PAK operation, by itself, is a significantly more straightforward and shorter operation than an SPK and the recipient is not uremic at the time of transplant. Also, the patients cardiac status has essentially undergone a pre-PAK stress test by virtue of the kidney transplant operation and

therefore there is increased assurance of being fit cardiovascularly. It is also possible that the recipient may achieve an immunological advantage because they are already on baseline immunosuppression prior to pancreas transplantation in the PAK group(19).

Historically, PAK transplants have been associated with inferior pancreas allograft survival compared to SPK transplants (in reports from 2003-2004, 78% vs. 85% 1-year graft survival, $p \leq 0.0001$)(20, 21) which was attributed to increased immunological pancreas graft loss in PAK recipients (in reports from 2003-2004, 5.2% vs. 1.8% at 1-year, $p \leq 0.0001$)(20, 21). In fact, this was true in our study as well, as it also included data from this early period. The separate donor origins of the pancreas and the kidney in the PAK recipients may account for some of these findings. Historically, following an SPK transplant, episodes of acute cellular rejection are more often detected and treated early because the recipients will manifest rejection of the transplanted kidney with a rise in serum creatinine, and the renal allograft is easily amenable to percutaneous biopsy whereas the pancreas was considered unsafe and difficult to biopsy. If the organs are from different donors, as is the case for PAK transplants, they may reject independently. One can conclude from this that if rejection is a frequent event and leads to graft loss, there would be an advantage to transplanting the kidney and the pancreas from the same donor, however the difference in immunological graft loss rates at 1 year between the two transplant types do not account for the entire difference in graft survival outcomes. Additionally, it is important to note, that although immunologic graft loss is more common in PAK (1 year – 5.5%) compared to SPK (1 year – 2%), this rate has been improving with time for PAK (1 year immunological graft loss rates in 1994 were 28% for PAK and 4.87% for SPK) (18). During the last decade, there have been a number of

publications describing advances in immunosuppression management following pancreas transplantation. The current direction of the field is induction with T-cell depleting antibody with steroid withdrawal (22-31). The depleting antibodies used include rabbit anti-thymocyte globulin (22, 24, 25, 28, 29, 32) or alemtuzumab (anti-CD 52) (23, 26, 27, 31). One of these studies was also calcineurin inhibitor free using alemtuzumab and MMF as maintenance immunosuppression (26), and another used alemtuzumab induction with monotherapy tacrolimus maintenance (31). Of note, all of these studies demonstrated better pancreas allograft survival than that predicted by the International Pancreas Transplant Registry (IPTR) (21). In addition, of the 365 patients described in all of these studies, there were only 5 immunologic grafts losses (1.3%), which is again better than expected according to the IPTR (21). Of the two studies that permit comparison between PAK and SPK pancreas allograft survival rates, the PAK group fared better in both cases (91% vs 81% and 100% vs 90% respectively) (26, 31). These data suggest that we have entered a new era of immunosuppression where immunological graft loss is an infrequent occurrence. These data are further supported by more recent IPTR reports using T-cell depleting antibody induction protocols, particularly in the context of maintenance immunosuppression protocols that include sirolimus where the 1 year pancreas graft survival rates have improved compared to the entire pancreas transplant recipient population from 80% to 89.3% for PAK and from 85.5% to 89.6% for SPK(18).

PAK and SPK transplants result in similar patient survival, and both outcomes are superior to patient survival of kidney transplantation alone. We were somewhat surprised by the splaying of the patient survival curves beyond 4 years comparing SPK to PAK, but

we also must acknowledge that in looking at 10 year survival, this may be misleading. It is likely that the increased incidence of pancreas allograft failure was a major contributor to this finding and, as discussed previously, this has improved significantly during the study period. In fact, it would be very interesting to reevaluate these data in another 10 years' time or focusing in on specific immunosuppression regimens. Ultimately, achieving freedom from dialysis and insulin independence should be the goal for all eligible type 1 diabetic uremic patients seeking transplantation therapy, as this provides the optimal patient survival benefit.(6) If achieving freedom from dialysis and insulin independence is the ultimate goal, patients should be offered either: 1) living donor kidney followed by pancreas transplantation if medically suitable and no contraindications have developed in the interim, or 2) SPK transplantation, if no living donor is available, the patient desires one operation or the expected waiting time is short. Both options provide excellent kidney graft survival and the possibility of potential preemptive kidney transplantation, and freedom from diabetes. In centers and regions where the waiting times for an SPK can be quite long, a PAK transplant can afford a patient a much shorter period on the waiting list (patient survival beyond one year on the SPK waiting list deteriorates rapidly). Elimination of dialysis and insulin requirements should be the dual goals for all medically suitable patients with uremic type-1 diabetes, whether this is achieved with a PAK or SPK.

The present study extends beyond the original JAMA publication by extending the follow-up from 4 to 10 years and uniquely looking at a new comparison for the PAK group (PAKs vs WL SPK candidates). Based on these data, not performing a PAK transplant represents a missed opportunity. The decline in PAK transplantation is a

leading contributor to the decreased volume trend in pancreas transplantation overall and reversing this trend represents an important opportunity for increasing the number of pancreas transplants.

A general limitation of the analysis is picking an appropriate comparison group for transplanted PAK recipients. There can be several different comparison groups such as kidney alone transplants with diabetes and no intent to get a pancreas, waitlisted SPK candidates, or candidates who received a kidney and are waiting for a pancreas. The analyses here expand on previous analyses by including the latter two of the three comparison groups mentioned above. In the last of these comparison groups, only those who are healthy enough to get a PAK are included in the PAK transplanted group, which could potentially bias the results because it does not include the patients that experienced kidney graft loss before the pancreas transplant. However, the same is true of the comparison group of prior kidney transplant recipients who are eligible for a PAK. Nonetheless, this analysis is retrospective. With these limitations in mind, the results support the notion that PAK transplants are an appropriate option for some diabetic uremic candidates who have a suitable living donor and are expected to have a long wait time for an SPK transplant, thereby achieving rapid reversal of uremia and reducing excess mortality. Receiving a subsequent pancreas after kidney transplant is associated with increased kidney graft survival and no increase in long-term mortality for PAK recipients.

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Disclosure:

Dr. Jon Odorico is the Primary Investigator on a Veloxis study and is the co-founder, chief scientific officer, chair of the scientific advisory board and has stock equity in Regenerative Medical Solutions, inc.

Table 1: Demographic Information by Expected Transplant Procedure Type.

Variable	PAK N=5636	SKP N=19725	P overall
GENDER:			0.016
Female	2403 (42.6%)	8053 (40.8%)	
Male	3233 (57.4%)	11672 (59.2%)	
Ethnicity:			<0.001
White	4728 (83.9%)	14629 (74.2%)	
Black	480 (8.52%)	2956 (15.0%)	
Hispanic	339 (6.01%)	1681 (8.52%)	
Asian	43 (0.76%)	229 (1.16%)	
Other	46 (0.82%)	230 (1.17%)	
Listing Age	41.8 (8.10)	40.2 (8.42)	<0.001
ABO:			<0.001
A	2265 (40.2%)	7145 (36.2%)	
AB	220 (3.90%)	721 (3.66%)	
B	645 (11.4%)	2383 (12.1%)	
O	2506 (44.5%)	9476 (48.0%)	
BMI:	25.2 (4.24)	24.9 (4.25)	<0.001
Transplanted:			<0.001
No	2278 (40.4%)	7417 (37.6%)	
Yes	3358 (59.6%)	12308 (62.4%)	
Allocation PRA			<0.001
0	1785 (67.6%)	6383 (76.0%)	
1-19	518 (19.6%)	1206 (14.4%)	
20-79	251 (9.50%)	597 (7.11%)	
80+	87 (3.29%)	209 (2.49%)	
HLA Mismatch			<0.001
0	49 (1.47%)	215 (1.77%)	
1	104 (3.13%)	157 (1.29%)	
2	277 (8.33%)	412 (3.40%)	
3	632 (19.0%)	1599 (13.2%)	
4	866 (26.1%)	3187 (26.3%)	
5	918 (27.6%)	4129 (34.0%)	
6	478 (14.4%)	2433 (20.1%)	

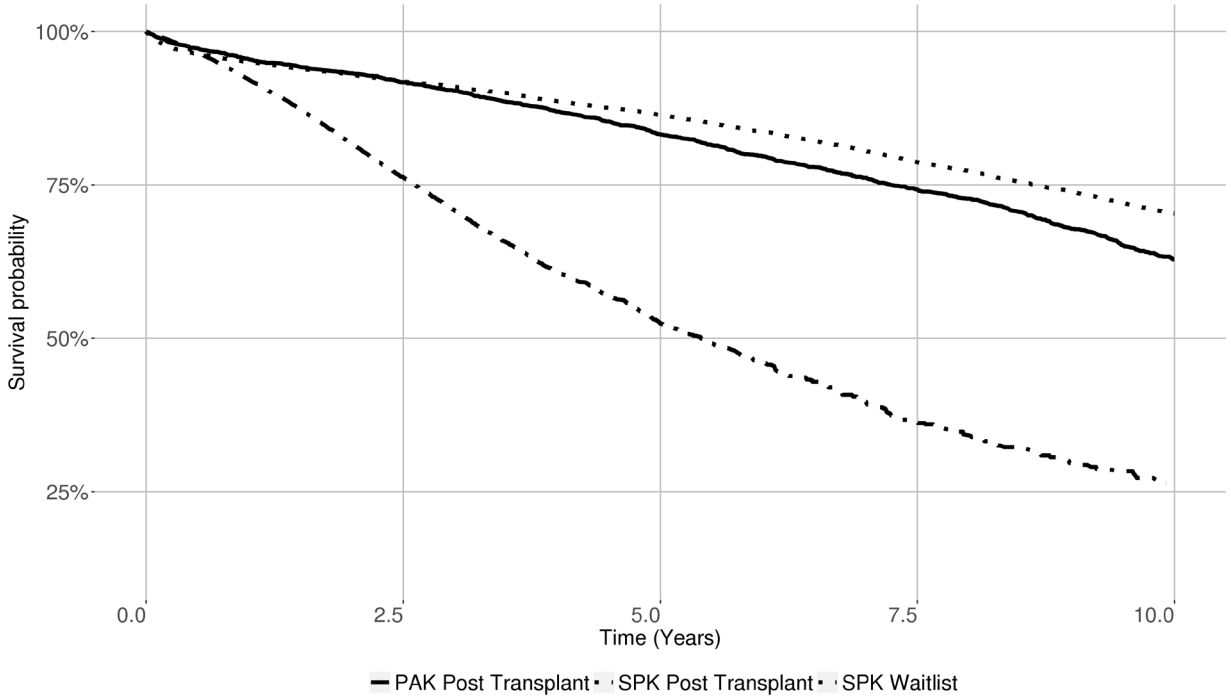
Figure legends:

Figure 1: SPK Waitlist survival and post-transplant survival for PAK and SPK post-transplant recipients.

Figure 2A: Kidney graft survival for SPK and PAK candidate groups. Groups are: 1) Type 1 DM deceased donor kidney transplant alone (Deceased KI-No PA), 2) Deceased donor kidney transplant followed by pancreas after kidney transplant (Deceased KI-PA TX), 3) Type 1 DM live donor kidney transplant alone (Living KI-No PA), 4) Live donor kidney transplant followed by pancreas after kidney transplant (Living KI-PA TX) and 5) Simultaneous pancreas-kidney transplant (SPK-KI).

Figure 2B: Pancreas graft survival for SPK and PAK candidate groups. Groups are: 1) Deceased donor kidney transplant followed by pancreas after kidney transplant (Deceased donor KI-PAK), 2) Live donor kidney transplant followed by pancreas after kidney transplant (Living donor KI-PAK), 3) Simultaneous pancreas-kidney transplant (SPK-PA).

Figure 3: Patient Survival from Transplant



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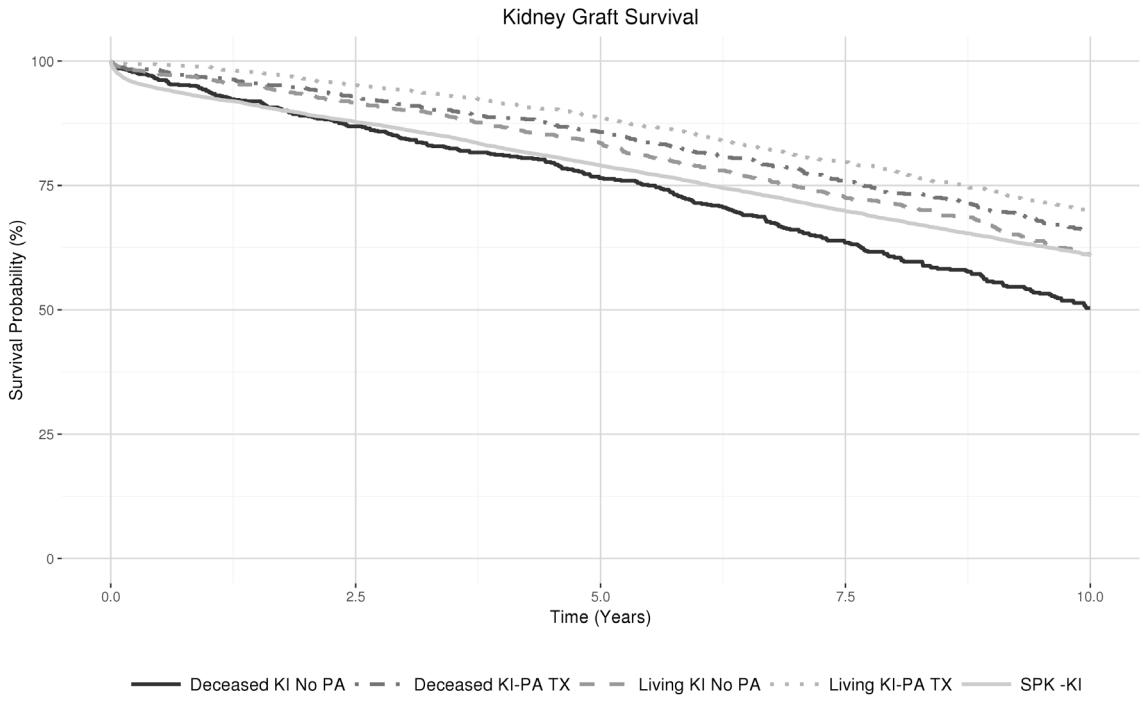

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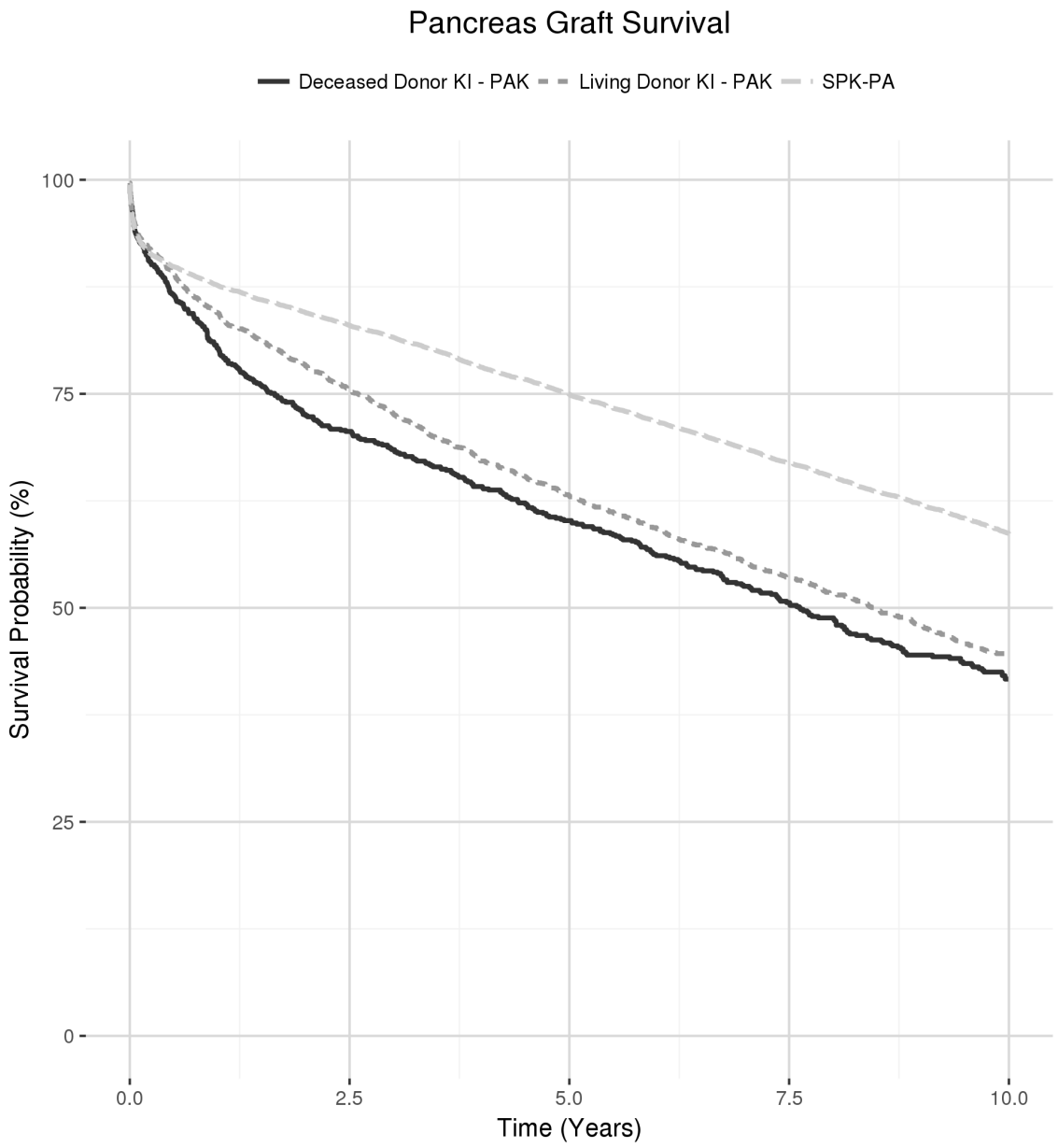

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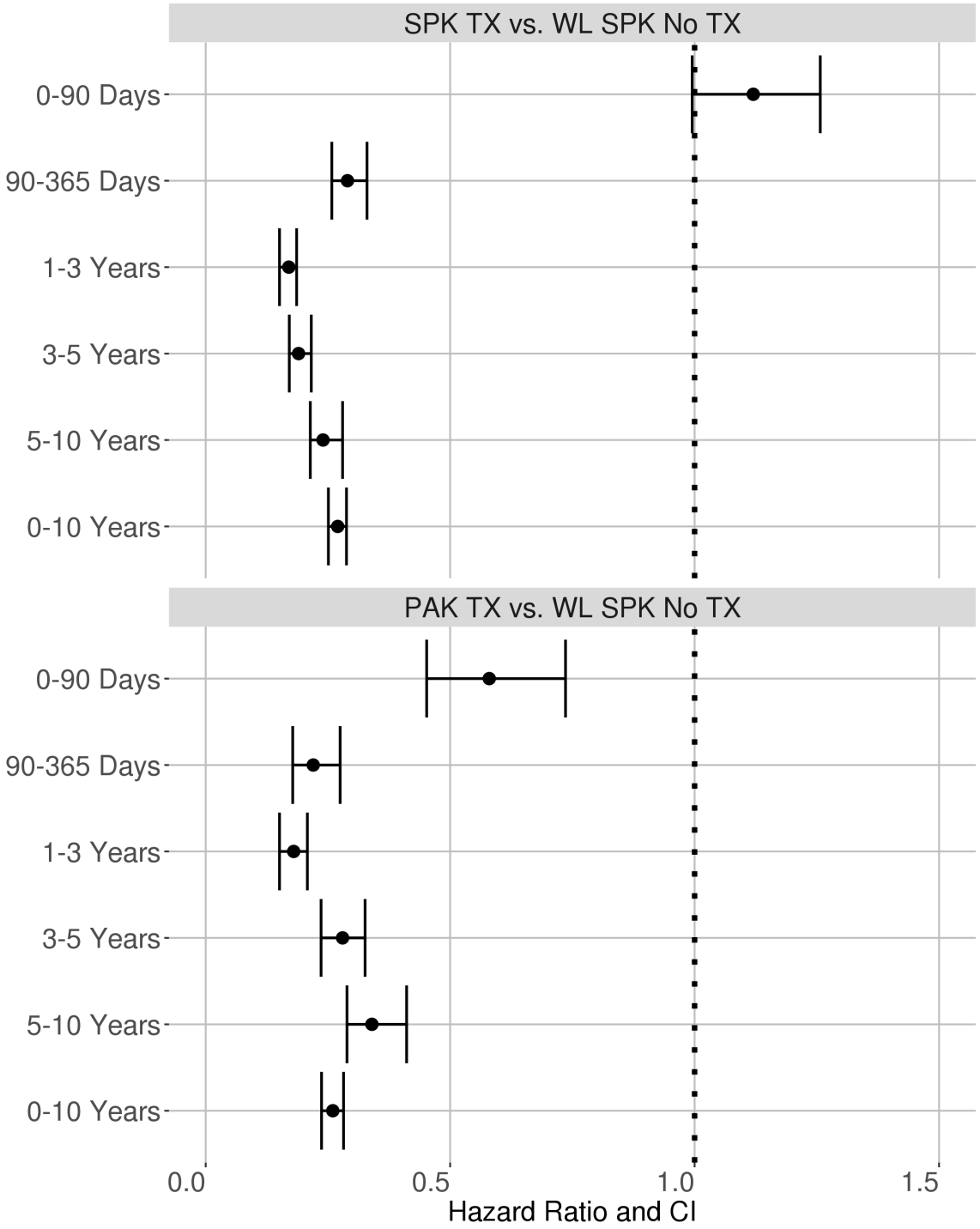

Figure 3: Patient Survival from Transplant

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