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Public Comment Proposal

Guidance on the Benefits of Pancreas After Kidney (PAK) Transplantation

OPTN/UNOS Pancreas Transplantation Committee

Prepared by: Abigail C. Fox, MPA
UNOS Policy Department

Michael Curry, MS
UNOS Research Department

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Guidance on the Benefits of Pancreas After Kidney (PAK) Transplantation

Affected Policies: *N/A*
Sponsoring Committee: *Pancreas Transplantation*
Public Comment Period: *July 31, 2017 – October 2, 2017*

Executive Summary

There has been a substantial decline in Pancreas After Kidney (PAK) transplants for more than a decade. PAK transplants have dropped steadily each year, with a 55% decrease from 2004 to 2011, even while 2-year pancreas graft survival increased for PAKs from 69% to 81% for the same time period.[1] PAK transplantation has historically been associated with inferior pancreas allograft survival compared with Simultaneous Pancreas and Kidney (SPK) transplantation. The Pancreas Committee sought to compare PAK transplants with SPK candidates and kidney alone recipients waiting for a pancreas to examine what characteristics resulted in improved outcomes for PAK recipients and to address an influential previous study that demonstrated poor outcomes for PAK recipients.

UNOS research analysis showed that PAK transplant recipients have an increased survival advantage compared to SPK waiting list candidates who receive neither a pancreas nor a kidney. Moreover, compared to uremic diabetic waitlist candidates, SPK and PAK recipients showed similar patient survival benefits. Finally, the analysis showed that both living and deceased donor kidney recipients who subsequently receive a pancreas transplant have better kidney graft survival than those recipients who just received a kidney alone. While the analysis does not include recipients that had a kidney graft loss before the pancreas transplant, which can bias the results to those healthy enough to get a PAK that are included in the PAK group, the results still indicate that PAK transplants are appropriate for certain diabetic uremic candidates, especially those with long SPK waiting list times. The Committee seeks to provide guidance to the community on the benefits of PAK transplants for these candidates.

[1] Gruessner, A.c., and R.w.g. Gruessner. "Declining Numbers of Pancreas Transplantations but Significant Improvements in Outcome." Transplantation Proceedings 46, no. 6 (August 2014): 1936-937. doi:10.1016/j.transproceed.2014.06.045.

Is the sponsoring Committee requesting specific feedback or input about this resource?

The Committee is not requesting specific feedback.

What problem will this resource address?

There has been a substantial decline in PAK transplants for more than a decade. PAK transplants have dropped steadily each year, with a 55% decrease from 2004 to 2011, even while 2-year pancreas graft survival increased for PAKs from 69% to 81% for the same time period.[2] PAK transplantation has historically been associated with inferior pancreas allograft survival compared with SPK transplantation.[3] For pancreas graft survival, the 1-year outcomes for SPK transplant (96.4%) compared to PAK transplant (87.3%) are similar, but at 5 years, the divide is greater for PAK (61.4%) compared to SPK outcomes (80.4%).[4] There are single center studies that show better outcomes for PAK recipients,[5] but the improvements have not been shown at the national level to date. The study described in this guidance document seeks to reproduce a 2003 study that found poor outcomes for PAK recipients, but with an added waiting list comparison group (PAK transplanted group being compared to waitlisted SPK candidates), kidney and pancreas graft survival, and an extended survival analysis to 10 years. The UNOS research analysis indicates that PAK transplants are underutilized for diabetic uremic candidates waiting for both a kidney and a pancreas, particularly those experiencing longer waiting times.

Why should you support this resource?

The analysis showed that a successful PAK transplant offers a survival advantage compared to those who receive neither a kidney nor a pancreas transplant. This comparison has not previously been made, and it highlights similarities in survival outcomes to SPK recipients and the overall benefits of uremic diabetic recipients receiving both a pancreas and kidney transplant either sequentially or simultaneously. Furthermore, the comparison of kidney graft survival by transplant type suggests that receiving a pancreas transplant may have a protective effect on the kidney graft.

PAKs represent a significant portion of the decline of pancreas transplantation over the last decade.[6] Diabetic uremic candidates may be appropriate candidates for a living donor kidney followed by a pancreas transplant, but choose to only receive the living donor kidney because of certain perceptions about whether PAK transplants are beneficial. Survival for SPK candidates can significantly worsen after one year on the waiting list, but SPK candidates or their doctors may not consider a PAK as a viable option. Increasing PAK transplantation for appropriate candidates can slow the decline in pancreas transplantation, increase the number of transplants overall, and, when done following a living donor kidney transplant, result in a deceased donor kidney being released to the deceased donor pool for kidney transplant recipients.[7] This guidance document provides valuable information to transplant physicians and their patients about the options for using PAK and when it may be an appropriate choice for diabetic uremic candidates. By performing analyses that were previously not explored, this resource highlights how PAK transplants are underutilized.

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[2] Gruessner, 1936-937.
[3] Curry, Michael. UNOS Research, 2016 OPTN Data.

[4] Ibid.
[5] Fridell, Jonathan A., Richard S. Mangus, Edward F. Hollinger, Tim E. Taber, Michelle L. Goble, Elaine Mohler, Martin L. Milgrom, and John A. Powelson. "The case for pancreas after kidney transplantation." Clinical Transplantation 23, no. 4 (May 13, 2009): 447-53. doi:10.1111/j.1399-0012.2009.00996.x.
[6] Stratta, Robert J., Jonathan A. Fridell, Angelika C. Gruessner, Jon S. Odorico, and Rainer W.g. Gruessner. Pancreas transplantation: A Decade of Decline. Current Opinion in Organ Transplantation 21, no. 4 (August 2016): 386-92. doi:10.1097/mot.0000000000000319.
[7] Fridell, 447-53.

How was this resource developed?

The Committee reviewed a potential new project on addressing PAK decline at an October 2015 in-person meeting. The Committee viewed the substantial decline in PAK transplants over the last decade as a significant issue and supported developing a project to address it. In January 2016, the Committee decided to review the literature regarding PAK transplants, including the most significant paper from 2003 that demonstrated a higher risk of death for PAK recipients compared to candidates on the waiting list who never received a pancreas transplant.[8] The decline in PAK transplants coincided with this paper and several rebuttals have been published in response, but no reversal of the decline of PAK transplantation has been seen.[9] [10]

The Committee requested data on PAK recipient and graft outcomes compared to kidney alone and pancreas alone transplants. Kaplan-Meier and Cox proportional Hazard models were used to analyze OPTN data from 1995-2010 to determine if receiving a transplant was more beneficial compared to staying on the waitlist. The analysis compared adult candidates and recipients for Pancreas Transplant Alone (PTA), PAK, and SPK procedures.

At an October 2016 in-person meeting, the Committee discussed the results of the data request. The significant result of the data was that candidates who receive a PAK have longer survival compared to candidates who do not receive either a kidney or a pancreas. Additionally for PAK candidates, receiving a living donor kidney increases both kidney and pancreas graft survival, and receiving a pancreas increases kidney graft survival. The Committee asked for an adjusted data request to include p-values, SPK graft survival, and to remove PTA.

At a March 2017 in-person meeting, the Committee reviewed the adjusted data analysis. The data request extended the time frame to look at 10 year outcomes comparing PAK and SPK with staying on the waitlist. The hazard ratio table compared SPK intention to treat (ITT) with PAK ITT. The Committee expressed concern about comparing SPK ITT with PAK ITT and asked the research liaison to remove the ITT analysis for a more “apples to apples” comparison. A Committee member suggested having the analysis show whether kidney graft survival would be adversely affected by receiving a pancreas after the kidney. The Committee requested an updated analysis to include recipient mortality and kidney graft failure, kidney function for PAK and SPK recipients, and to remove the ITT analysis.

On June 12, 2017, the Committee reviewed the updated data request and guidance document. The Committee supported the guidance document but wanted to make specific changes before voting to send the guidance out for public comment. Specifically, they asked that the second panel in the figure illustrating recipient survival by hazard ratios be removed. This panel compared PAK recipients to PAK candidates on the waitlist, whereas the other hazard ratio panels compared to the SPK waiting list. Based on the feedback from the Committee, the guidance document was revised to include a limitations section and a revised hazard ratio graph.

On June 26, 2017, the Committee discussed the revised guidance document, and expressed support for the changes. The Committee asked that a figure depicting waitlist survival for PAK and SPK candidates as well as post-transplant survival for PAK and SPK recipients be modified. The Committee felt the PAK waitlist figure was misleading. PAK waiting list candidates are already kidney recipients and therefore tend to have higher survival than SPK candidates waiting for both a kidney and a pancreas. The figure was changed to depict SPK waiting list survival and post-transplant survival for PAK and SPK recipients. With this last additional change, on June 30, 2017 the Committee voted unanimously for the guidance document to go out to public comment.

[8] Venstrom JM, McBride MA, Rother KI, Hirshberg B, Orchard TJ, Harlan DM. Survival after pancreas transplantation in patients with diabetes and preserved kidney function. JAMA 2003; 290 (21): 2817-23.

[9] Gruessner RWG, Sutherland DER, Gruessner AC. Mortality assessment for pancreas transplants. Am J Transplant 2004; 4: 2018-2026.

[10] Stratta, 386-92.

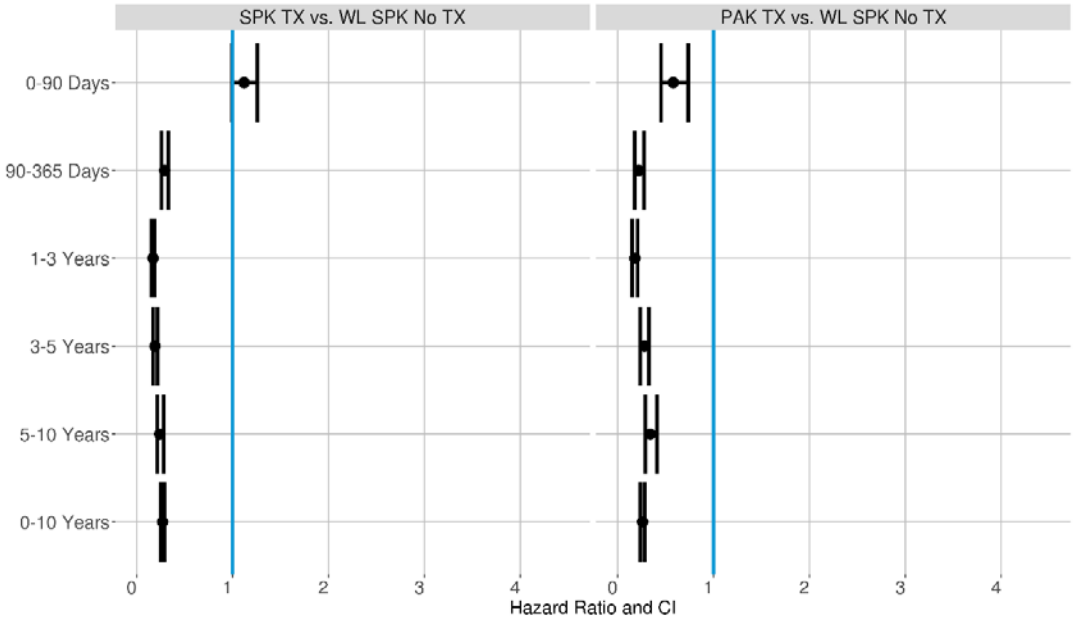
How well does this resource address the problem statement?

A significant factor in the decline of PAK transplants is the perception that PAKs recipients experience worse survival rates than diabetic uremic patients on the SPK waiting list or pursuing other medical therapies. The guidance document directly addresses this perception that by showing that PAK recipients' survival is significantly better than candidates on the waiting list. The guidance document also shows that PAKs have a positive impact on kidney graft survival. This guidance document seeks to clarify misconceptions about PAK outcomes and combat the decline of PAKs and pancreas transplantation generally by showing that PAKs are underutilized and may be an appropriate choice for diabetic uremic candidates.

Kaplan-Meier and Cox proportional hazard models were used to analyze OPTN data from 1995-2010 to determine if receiving a transplant was more beneficial compared to staying on the waitlist. The analysis compared adult candidates and recipients for PAK and SPK procedures.

Kaplan-Meier analysis among PAK recipients demonstrated that receiving a pancreas after kidney is associated with an increased kidney graft survival over 5 years compared to recipients who only received a kidney and no pancreas. This pattern was observed regardless of the type of kidney transplant received (living donor vs. deceased donor). Moreover, receiving a living donor kidney was associated with increased pancreas graft survival over 5 years compared to receiving a deceased donor kidney. With regard to mortality after transplant vs. remaining on the waiting list (WL), Figure 1 shows the hazard ratio of recipient survival from listing by SPK and PAK transplant types. Panel one compares SPK recipients to WL SPK candidates who did not receive a transplant (WL SPK No TX). The second panel compares PAK recipients to WL 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.

Figure 1: Recipient Survival from Transplant



In Figure 1, at each time point the hazard ratio is comparing the number of candidates who died on the waitlist over the number of candidates who were waiting at that time point to the number of recipients who died during that time point over the number of people transplanted in that time frame. A ratio between 0 and 1 indicates a benefit of transplantation compared to staying on the waitlist. A ratio greater than one favors conventional therapies over transplantation. If the confidence intervals overlap with 1, transplantation as a treatment option is considered neutral.

Among the SPK group, survival at 90 days demonstrated no benefit of transplant compared to staying on the waitlist (HR =1.12, CI = [0.996, 1.25]). However, after the first 90 days, there was overwhelming

statistical support for getting the SPK transplant 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 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 compared to 12,308 number of SPK recipients of which 3,049 died.

When comparing PAK recipients to SPK waitlisted candidates who did not receive a transplant there was support for PAK transplant at each time interval. Specifically, at 90 days the hazard was 0.58 CI [0.45-0.73], then until one year (90 to 365 days) the hazard was HR = 0.22 CI [0.17-0.27], after one year (1 to 3 years) the hazard was 0.18 CI [0.15-0.20]; at 3 to 5 years it was 0.28 CI [0.23-0.32] and the 5 to 10 year hazard was 0.34 CI [0.28-0.41]. A total of 953 recipients died after PAK transplants out of 3,358 transplants at 10 years compared to 2,881 SPK candidates out of 7,417 SPK candidates who were waiting for a transplant.

Figure 1 indicates that PAK transplant recipients who receive both organs have an increased survival advantage compared to uremic candidates who receive neither a pancreas nor a kidney (2nd panel). Moreover, compared to uremic diabetic WL candidates, SPK and PAK recipients showed similar overall survival benefits (1st panel versus 2nd panel).

The data analysis showed that a successful PAK transplant offers a survival advantage compared to those who receive neither a kidney nor a pancreas transplant. This comparison has not previously been made, and it highlights similarities in recipient survival outcomes to SPK recipients and the overall benefits of uremic diabetic recipients receiving both a pancreas and kidney transplant either sequentially or simultaneously. Furthermore, the comparison of kidney graft survival by transplant type suggests that receiving a pancreas transplant may have a protective effect on the kidney graft.

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 two of the three comparison groups mentioned above (comparing PAK recipients to WL SPK groups and to WL PAK candidates). Additionally, only those who are healthy enough to get a PAK are included in the PAK transplanted group, which can bias the results because it does not include the candidates that had a kidney graft loss before the pancreas transplant. However, even with these limitations the results still indicate that PAK transplants are appropriate for specific diabetic uremic candidates who are expected to have a long wait time for an SPK transplant. Quickly receiving a kidney will mitigate mortality and getting the pancreas after the kidney transplant will increase the kidney graft survival for PAK recipients.

Which populations are impacted by this resource?

This guidance document impacts candidates in need of both a kidney and a pancreas transplant. At the end of 2015, there were 1,911 candidates on the waiting list for a SPK and 396 candidates for a PAK.[11]

Increasing PAK transplantation for appropriate candidates can slow the decline in pancreas transplantation and, when done with a living donor kidney, result in a deceased donor kidney being released to the deceased donor pool for kidney transplant recipients.[12] By performing analyses that were previously not explored, this resource highlights how PAK transplants are underutilized. This project is expected to promote PAK transplants as a viable and beneficial means of transplantation for kidney-pancreas candidates, increasing the number of transplants performed.

[11] Kandaswamy, Stock, P.G., Gustafson, S. K., Skeans, M. A., Curry, M. A., Prentice, M. A., Israni, A. K., Snyder, J. J., Kasiske, B. L. “OPTN/SRTR 2015 Annual Data Report: Pancreas.”

[12] Fridell, 447-53.

How does this resource impact the OPTN Strategic Plan?

1. *Increase the number of transplants*: This project is expected to promote PAK transplants as a viable and beneficial means of transplantation for kidney-pancreas candidates. Because PAKs follow kidney-alone transplants, these transplants do not occur at the expense of other transplants. Pancreases are often discarded and increasing PAKs will increase utilization of pancreases, thus increasing the number of transplants overall.
2. *Improve equity in access to transplants*: There is no impact to this goal.
3. *Improve waitlisted patient, living donor, and transplant recipient outcomes*: Guidance on the improved outcomes of PAK transplants will increase the utilization of pancreata and promote increased transplant benefit across the population.
4. *Promote living donor and transplant recipient safety*: There is no impact to this goal.
5. *Promote the efficient management of the OPTN*: There is no impact to this goal.

How will the OPTN implement this resource?

This proposal will not require programming in UNet^{SM}. There may be a small educational component to support members of the transplant community utilizing the guidance document.

How will members implement this resource?

Transplant Hospitals

Transplant hospitals may elect to use this as a resource for staff at their transplant programs. Use of this document is optional and is intended to provide information that can be used in discussions with candidates and when considering organ offers. A small amount of resources may be required to disseminate this information to transplant program staff.

Will this resource require members to submit additional data?

No, this proposal does not require additional data collection.

How will members be evaluated for compliance with this resource?

Guidance from the OPTN does not carry the weight of policies or bylaws. Therefore, members will not be evaluated for compliance with this document.

How will the sponsoring Committee evaluate whether this resource was successful post implementation?

It will be challenging to establish causation of a change in organ acceptance practices based on this guidance document and corresponding education/outreach. In order to assess if the guidance and related education/outreach has positively impacted organ donation and transplantation, the Committee will monitor the number of PAKs performed. UNOS staff will report this information to the Committee at one year intervals following approval by the Board.

Guidance Document

Guidance on the Benefits of Pancreas after Kidney (PAK) Transplantation

Contents

Guidance on the Benefits of Pancreas after Kidney (PAK) Transplantation

Abstract

A prior publication suggested that a sequential pancreas transplant after a kidney transplant (PAK) is associated with worse short-term patient survival and indifferent long-term patient survival compared to patients on the waitlist,[1] but the data supporting these associations may be subject to an important selection bias due to the waiting list used for analysis and an inadequate follow-up period.[2] In this Organ Procurement and Transplantation Network (OPTN) database analysis, which attempts to correct for these factors, PAK and simultaneous pancreas and kidney (SPK) patient outcomes were similar, and both options represented a significant improvement over the excess patient mortality of uremic diabetic patients on dialysis. Additionally, PAK recipients following living donor kidney transplants seemed to have better pancreas graft survival outcomes than PAK recipients following deceased donor kidney transplants and the best kidney transplant outcomes were observed in the PAK after living donor kidney combination. Thus, PAK transplants are currently underutilized and should be considered as a treatment option for uremic diabetic patients.

Introduction

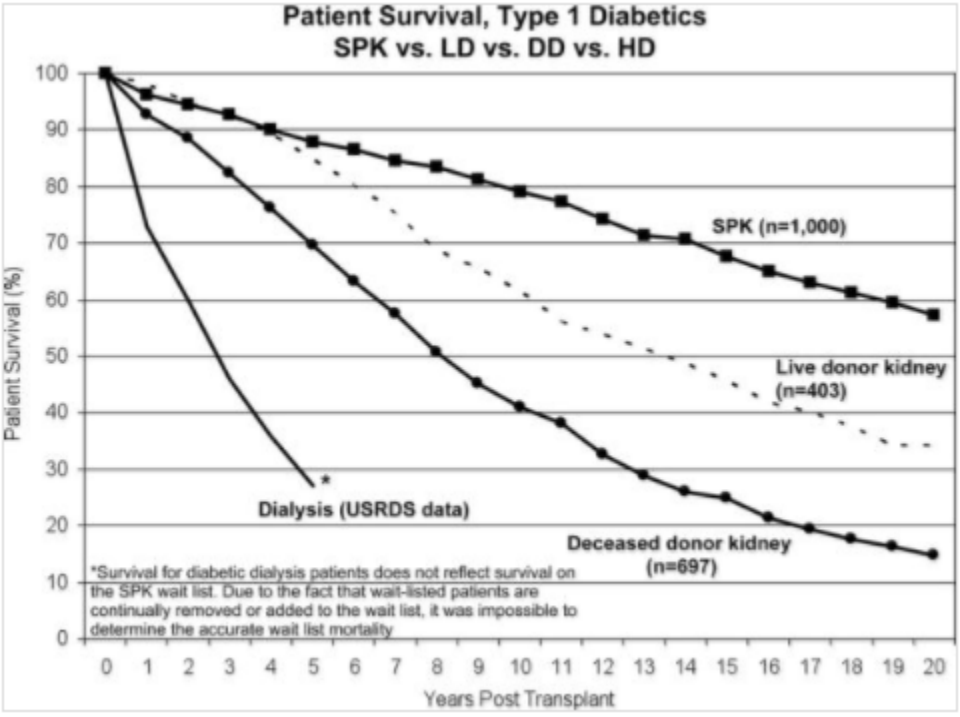
Beginning in 2004, there has been a profound decline in the number of pancreas transplants performed in the United States.[3] There is a perception in the pancreas transplant community that the overall decline in pancreas transplantation, particularly PAK transplantation, occurred immediately following publication of a study funded by the National Institutes of Health in a Journal of the American Medical Association (JAMA) article published in 2003.[4] This study was a retrospective observational study performed as a query to the OPTN database comparing survival rates at 1 and 4 years post-transplant and the relative risk of death between patients on the waiting list 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.[5] A subsequent rebuttal study employing a similar study design came to a contradictory conclusion indicating that PAK transplanted recipients did not have increased mortality compared to those waiting for a PAK.[6] Although there have been rebuttals and reviews of the JAMA paper, none seem to have helped increase the number 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.[7] For example, the University of Wisconsin published their experience with one thousand kidney-pancreas transplantations with 22 year follow-up.[8] In this report, 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 cadaveric renal transplantation

[1] Venstrom JM, McBride MA, Rother KI, Hirshberg B, Orchard TJ, Harlan DM. Survival after pancreas transplantation in patients with diabetes and preserved kidney function. JAMA 2003; 290 (21): 2817-23.
[2] Gruessner RWG, Sutherland DER, Gruessner AC. Mortality assessment for pancreas transplants. Am J Transplant 2004; 4: 2018-2026.
[3] Stratta, Robert J., Jonathan A. Fridell, Angelika C. Gruessner, Jon S. Odorico, and Rainer W.g. Gruessner. Pancreas transplantation: A Decade of Decline. Current Opinion in Organ Transplantation 21, no. 4 (August 2016): 386-92. doi:10.1097/mot.0000000000000319.
[4] Ibid.
[5] Venstrom, 2819-2820.
[6] Gruessner, 2018-2026.
[7] Fridell, Jonathan A., and John A. Powelson. Pancreas after kidney transplantation. Current Opinion in Organ Transplantation 20, no. 1 (February 2015): 113. doi:10.1097/mot.0000000000000160.
[8] Sollinger HW, Odorico JS, Becker YT, D'Alessandro AM, Pirsch JD. One thousand simultaneous pancreas-kidney transplants at a single center with 22-year follow-up. Ann Surg. 2009 Oct;250(4):618-30. PubMed PMID: 19730242. Epub 2009/09/05. eng.

and dialysis.[9] 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 in this particular study the 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 alone, supporting the fact that freedom from diabetes has a clear survival advantage.[10,11] Figure 1 shows the relative patient survival of SPK, live donor kidney (LD), deceased donor kidney (DD), and dialysis (HD) originally shown in the Wisconsin study.

Figure 1: Patient Survival in Wisconsin Study[12]



Furthermore, if a suitable diabetic uremic patient is evaluated for transplantation, they would have historically been offered the choice between a SPK transplant or, if they had a suitable living donor, living donor renal transplantation followed by PAK. Since this 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.[13] If they ultimately no longer require dialysis and are also not diabetic, there would be a greater patient survival advantage compared to remaining diabetic but free from renal failure.

The study described in this guidance document was intended to reproduce the original study from 2003 adding an additional waiting list comparison group (PAK transplanted group being compared to waitlisted SPK candidates), while also looking at kidney and pancreas graft survival and extending the survival analyses to 10 years.

[9] Ibid.
[10] Ibid.
[11] Stratta, 390.
[12] Reproduced with permission from Author(s). One thousand simultaneous pancreas-kidney transplants at a single center with 22-year follow-up. Annals of Internal Medicine. 2009; vol: 250-4. ©American College of Physicians.
[13] Venstrom, 2818.

Background

1) Methods

UNOS staff analyzed the OPTN database of 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 or a previous transplant. 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. Pancreas graft outcomes were determined from graft failures defined by individual centers as reported to UNOS.

The analysis did not exclude PAK candidates with a creatinine greater than 2 mg/dL. Because creatinine was not a required field before October 1999, excluding candidates with creatinine values above 2 mg/dL would incorrectly assume that all of those with a missing creatinine had values less than 2 mg/dL. 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
- Deceased donor SPK
- Living donor kidney alone
- Living donor kidney followed by a deceased donor pancreas
- Deceased donor kidney followed by a deceased donor pancreas

The impact for each of these transplant types was assessed considering kidney and pancreas graft survival as well as patient mortality. To accurately measure kidney graft survival, the PAK group was subdivided into 4 groups by kidney donor type:

1. Deceased donor kidney and pancreas
2. Deceased donor kidney with no pancreas
3. Living donor kidney and pancreas
4. Living donor kidney with no pancreas

A cox-proportional hazards model was used to determine if receiving a pancreas after a living or a deceased donor transplant impacted kidney graft survival, while a log-rank test was used to determine if receiving a living donor kidney 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. For the waitlisted candidates who did not receive a transplant, follow-up time was 10 years plus median time to transplant for the anticipated transplant type. 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.

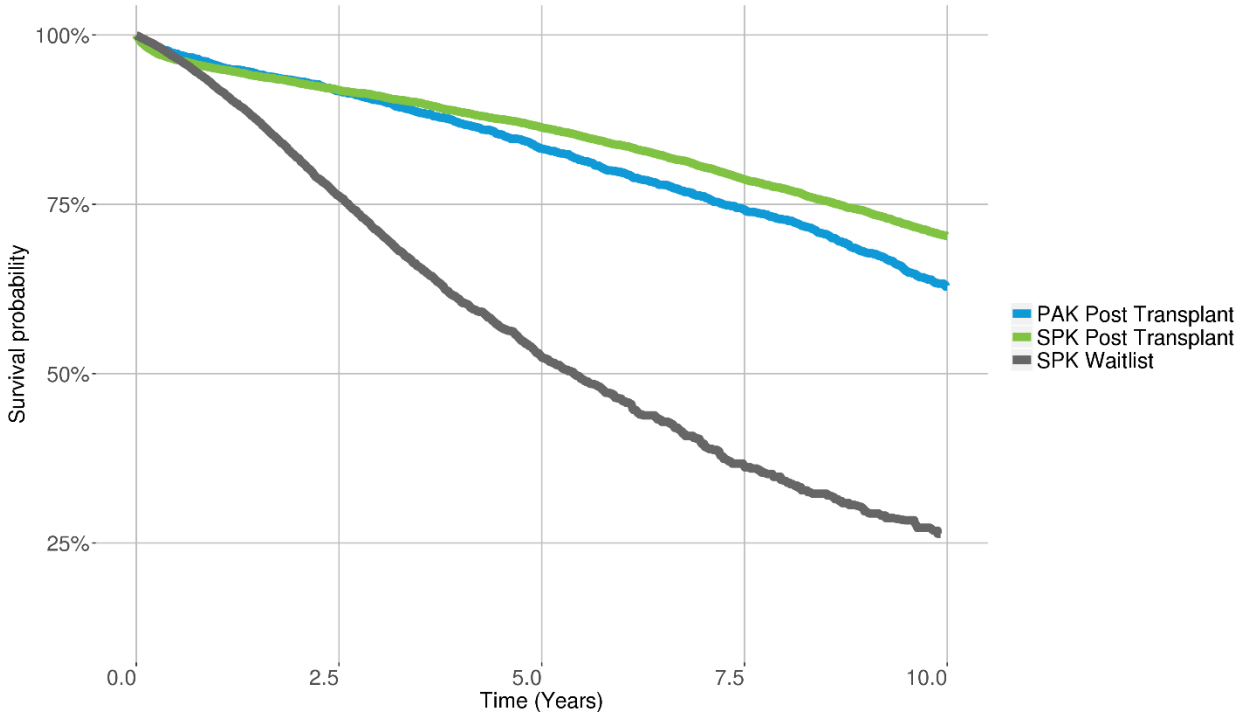
2) Results

The SPK and PAK waitlisted candidate groups were similar, yet based on the large number of subjects, it is not surprising there were 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.

Table 1: Demographic Information by Expected Transplant Procedure Type.

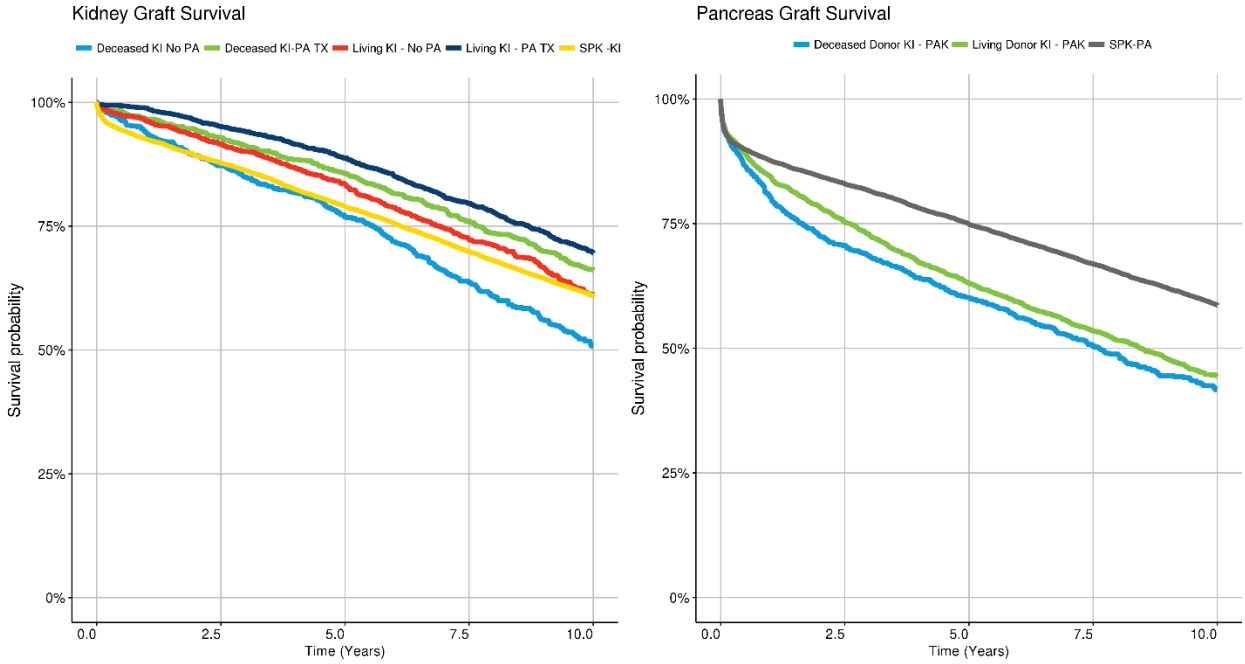
Variable	PAK N=5,636	SPK N=19,725	P overall
Transplanted:			<0.001
No	2,278 (40.4%)	7,417 (37.6%)	
Yes	3,358 (59.6%)	12,308 (62.4%)	
GENDER:			0.016
Female	2,403 (42.6%)	8,053 (40.8%)	
Male	3,233 (57.4%)	11,672 (59.2%)	
Ethnicity:			<0.001
White	4,728 (83.9%)	14,629 (74.2%)	
Black	480 (8.52%)	2,956 (15.0%)	
Hispanic	339 (6.01%)	1,681 (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	2,265 (40.2%)	7,145 (36.2%)	
AB	220 (3.90%)	721 (3.66%)	
B	645 (11.4%)	2,383 (12.1%)	
O	2,506 (44.5%)	9,476 (48.0%)	

Figure 2: SPK Waitlist survival (gray) and post-transplant survival for PAK (Blue) and SPK (Green) recipients.



Waitlist and post-transplant survival by transplant procedure type are shown in Figure 2. 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%). From the graphic above we can see that both transplanted groups had markedly higher patient survival compared to the waitlisted SPK group (PAK TX 63.2% vs. SPK WL 26.4% and SPK TX 70.3% vs SPK WL 26.4%).

Figure 3: Kidney graft survival (left) and pancreas graft survival (right) for SPK and PAK candidate groups

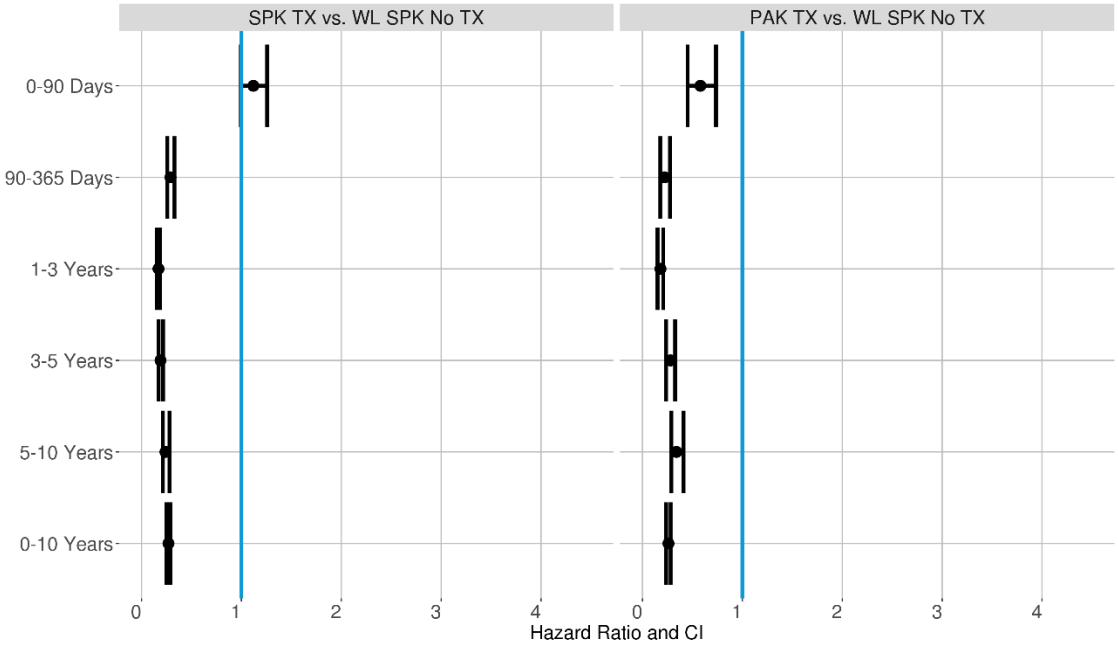


Kidney and pancreas graft survival for both PAK and SPK transplant types are shown in Figure 3. The cox-proportional hazard model comparing kidney donor type (living vs. deceased) and whether PAK candidates received a pancreas shows that receiving a living donor kidney was associated with improved kidney graft survival as expected (p-values < 0.001). Receiving a subsequent pancreas was also associated with improved long term kidney graft survival (p-value < 0.001) versus not receiving a subsequent pancreas transplant, regardless of whether the kidney was from a deceased or living donor. The interaction between donor type and pancreas transplantation was not significant (p-value = 0.09).

Ten-year kidney graft survival was 69.7% for recipients who received a living donor kidney and a pancreas compared to 61.1% for those who only received a living donor kidney. Additionally, 10-year kidney graft survival for recipients who received a deceased donor kidney transplant and then a pancreas was 66.1%, while kidney graft survival for recipients who just received a deceased donor kidney was 50.8%. SPK kidney graft survival was 61% at 10 years. Similarly for pancreas, a cox- proportional hazard model was used to determine if receiving a living donor kidney increased pancreas graft survival. At 10 years, PAK recipients who received a living donor kidney 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.

Figure 4 shows the hazard ratio of patient survival from listing by SPK and PAK transplant types. 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.

Figure 4: Patient Survival from Transplant



In Figure 4, at each time point the hazard ratio is comparing the number of candidates who died on the waitlist over the number of candidates who were waiting at that time point to the number of recipients who died during that time point over the number of people transplanted in that time frame. A ratio between 0 and 1 indicates a benefit of transplantation compared to staying on the waitlist. A ratio greater than one favors conventional therapies over transplantation. If the confidence intervals overlap with 1, transplantation as a treatment option is considered neutral.

Among the SPK group, survival at 90 days demonstrated no benefit of transplant compared to staying on the waitlist (HR =1.12, CI = [0.996, 1.25]). However, after the first 90 days, there was overwhelming statistical support for getting the SPK transplant 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 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 compared to 12,308 number of SPK recipients of which 3,049 died.

Although not shown when comparing PAK recipients to PAK candidates (those who received a kidney and are waiting for a pancreas) in the first 90 days, the hazard of death post-surgery was 3.1 CI [2.3-4.0] times greater than staying on the waitlist. 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 hazard was 1.19 CI [0.92-1.53], and from 1 to 3 years the hazard fell to 1.0 CI [0.81-1.23]. Longer term, the hazard of death from 3 to 5 years was 1.17 CI [0.93-1.45], and from 5 to 10 years 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, compared 953 who died out of the 3,358 post-transplant recipients for PAKs.

When comparing PAK recipients to SPK waitlisted candidates who did not receive a transplant there was support for PAK transplant at each time interval. Specifically, at 90 days the hazard was 0.58 CI [0.45-0.73], then until one year (90 to 365 days) the hazard was HR = 0.22 CI [0.17-0.27], after one year (1 to 3 years) the hazard was 0.18 CI [0.15-0.20]; at 3 to 5 years it was 0.28 CI [0.23-0.32] and the 5 to 10 year hazard was 0.34 CI [0.28-0.41]. A total of 953 recipients died after PAK transplants out of 3,358 transplants at 10 years compared to 2,881 SPK candidates out of 7,417 SPK candidates who were waiting for a transplant.

Figure 4 indicates that PAK transplant recipients who receive both organs have an increased survival advantage compared to uremic candidates who receive neither a pancreas nor a kidney (2nd panel). Moreover, compared to uremic diabetic waitlisted patients, SPK and PAK recipients showed similar overall patient survival benefits (1st panel versus 2nd panel, Figure 4).

Recommendation

From a patient survival outcome perspective, PAK transplants are an excellent alternative to SPK transplants for uremic diabetic patients, particularly if the SPK waiting time is expected to be > 1 year and the recipient has potential living kidney donors. Given the potential benefits of receiving a PAK for uremic diabetic patients, as well as the risks of staying on the waitlist, we recommend the use of PAK transplants for candidates who qualify and would benefit.

Conclusion

PAK and SPK result in similar patient survival, and both outcomes are superior to kidney transplantation alone.[14] Ultimately, achieving dialysis and insulin independence should be the goal for type 1 diabetic uremic patients seeking transplantation therapy, as this provides the optimal patient survival benefit.[15] If achieving 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). Every combination of a living donor kidney transplant followed by a PAK would also result in a donor kidney returning to the cadaveric donor pool for kidney transplant recipients. Elimination of dialysis and insulin requirements should be the dual goals for all medically suitable patients with uremic type-1 diabetes, whether that is achieved with a PAK or SPK.

This guidance extends beyond the original JAMA publication by extending the time frame from 4 to 10 years and looking at a new comparison for the PAK group (PAKs vs WL SPK candidates). PAK transplants are missed opportunities to offer appropriate candidates pancreas transplantation. The decline in PAK transplantation is clearly a leading contributor to the decreased volume trend in pancreas transplantation overall and 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 comparisons 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 a pancreas. The analyses here expand on previous analyses by including two of the three comparison groups mentioned above (comparing PAK to waitlisted SPK groups and to waitlisted PAK candidates). Additionally, only those who are healthy enough to get a PAK are included in the PAK transplanted group, which can bias the results because it does not include the patients that had a kidney graft loss before the pancreas transplant. However, even with these limitations the results still indicate that PAK transplants are appropriate for specific diabetic uremic candidates who are expected to have a

[14] Gruessner, 2024-2025.

[15] Fridell, 113.

long wait time for an SPK transplant. Quickly receiving a kidney will mitigate mortality and getting the pancreas after the kidney transplant will increase the kidney graft survival for PAK recipients.

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