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More than 25 years of pancreas graft survival after simultaneous pancreas and kidney transplantation: experience from the world's largest series of long-term survivors

Sandesh Parajuli, MBBS[1], **Natalie M. Bath, MD**[2], **Fahad Aziz, MD**[1], **Neetika Garg, MD**[1], **Brenda Muth, NP**[1], **Arjang Djamali, MD**[1,2], **Robert R. Redfield, MD**[2], **Dixon Kaufman, MD,PhD**[2], **Jon Odorico, MD**[2], **Didier Mandelbrot, MD**[1], **Hans Sollinger, MD, PhD**[2]

[1]Division of Nephrology, Department of Medicine, University of Wisconsin School of Medicine and Public Health, Madison, WI

[2]Division of Transplant Surgery, University of Wisconsin School of Medicine and Public Health, Madison, WI

Abstract

Background: The first simultaneous pancreas and kidney (SPK) transplant was performed in 1966. Early procedures were associated with significant morbidity and mortality and were performed in very low numbers in select patients.

Methods: This study includes all recipients of an SPK at the University of Wisconsin-Madison between 1986 and 1993 who were actively followed and had a functional pancreas allograft for more than 25 years as of 10/31/2018.

Results: A total of 291 SPK were performed during the study period; of these, 39 patients still had a functional graft at last follow up and nine (18.8%) pancreas grafts were lost due to patient death or graft failure after more than 25 years. At last follow up, all 39 patients with functional

Corresponding author's address, phone, and email: Sandesh Parajuli, MBBS, UW Medical Foundation Centennial Building 4175, 1685 Highland Avenue, Madison, WI 53705, Tel: 608-265-0152, sparajuli@medicine.wisc.edu.

Author contribution statement.

1. Parajuli: concept, design, data collection, manuscript preparation, editing
2. Bath: manuscript preparation, editing
3. Aziz: manuscript preparation, editing
4. Garg: manuscript preparation, editing
5. Muth: manuscript preparation, editing
6. Djamali: manuscript preparation, editing
7. Redfield: manuscript preparation, editing
8. Kaufman: manuscript preparation, editing
9. Odorico: manuscript preparation, editing
10. Mandelbrot: manuscript preparation, editing
11. Sollinger: concept, design, manuscript preparation, editing

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pancreas graft had at least one co-morbidity, such as hypertension, hyperlipidemia, or coronary artery disease. Twenty-seven required enteric conversion; 11 patients experienced renal allograft failure (10 underwent a repeat kidney transplant); and 6 required amputation of part of the lower extremity. In the Cox regression analysis, bladder drained pancreas was associated with lower probability of prolonged pancreas graft survival (HR: 0.52; CI: 0.32 to 0.85; p=0.01).

Conclusion: With careful and detailed follow-up and attention to complications, some recipients of pancreas grafts have outstanding outcomes. As the number of pancreas recipients with prolonged graft survival may be rising, health care providers should be aware of the management of complications associated with this unique group of patients.

Keywords

prolonged graft survival; pancreas transplant; complications

Introduction

Simultaneous pancreas and kidney (SPK) transplant is usually the best option for diabetic end-stage renal disease (ESRD) patients.[1] Pancreas transplantation, in the form of SPK transplant, is known to be an effective therapy that can reverse metabolic abnormalities, which may prevent or minimize many of the secondary complications of diabetes mellitus (DM).[2] SPK transplants prolong patient survival beyond the survival advantage associated with renal transplantation alone.[3] The five-year patient survival after SPK transplantation is 87% and 10-year patient survival is 70%, which is significantly better than the survival rates for patients with type 1 DM on maintenance dialysis who are on the transplant waiting list.[4,5]

The first SPK was performed in 1966 at the University of Minnesota;[6] however, early procedures were associated with significant morbidity and mortality and were performed in very low numbers.[3] With the evolution of immunosuppression medications and improvements in surgical techniques, pancreas graft survival continues to improve. However, the survival rate of long-term pancreas grafts remained almost unchanged among SPK recipients between 1995 and 2011, as indicated in a large study that detailed 22,000 pancreas transplants from the United Network of Organ Sharing (UNOS) database.[7] A similar result was found in a previous study of 14,311 diabetic patients who received a first-time SPK transplant between October 1987 and November 2007.[8] Despite these observations about overall rates, some SPK recipients are able to experience long-term pancreas graft survival and function, even decades after transplantation. In this single-center, historical study, we share our experience of SPK transplant recipients with a functional pancreas allograft for more than 25 years at last follow up as of 10/31/2018.

Methods

Study population, design, and data collection.

We analyzed data from simultaneous kidney and pancreas transplant recipients in the Wisconsin Allograft Recipient Database (WisARD). This single-center, historical, observational study included all recipients of an SPK at the University of Wisconsin-

Madison (UW) between 1986 and 1993 who were actively followed at the University Hospital & Clinics and had a functional pancreas allograft for more than 25 years as of 10/31/2018. Patients transplanted at a different center but followed at our center, patients transplanted at our center but lost to follow-up, or those whose care was transferred to a different center were excluded from the study. Demographic data including recipient age at the time of transplant and gender were collected, as well as data on induction and current immunosuppression regimens. Pancreas graft outcomes, current graft function, and mean pancreas graft survival were evaluated. Rejection, malignancy, amputation, kidney graft failure, infectious complications, and autoimmune disease development were studied. Diabetes-related complications and details regarding disease progression were collected. This study was approved by the Health Sciences Institutional Review Board at the University of Wisconsin.

Pancreas transplant program of the University of Wisconsin:

The University of Wisconsin (UW) has been performing pancreas transplants for more than 35 years. The first pancreas transplants at UW were performed in 1982[9] and the UW has remained active in pancreas transplantation ever since. In the first 25 years of pancreas transplantation, 1,249 pancreas transplants were performed at UW, mainly as SPK.[9] UW also has a high-volume outpatient clinic for SPK recipients.

Clinic follow-ups and monitoring:

We follow our pancreas transplant recipients at either the University Hospital or regional outreach clinics at least once a year until graft failure or patient care is transferred to a different transplant center.

Induction and maintenance immunosuppression.

Our induction and maintenance immunosuppression regimens have evolved over time. In the past, we used depleting agents in all pancreas transplant recipients. Minnesota anti-lymphocyte globulin (MALG) was used as induction immunosuppressive medication in the mid-1980s, and was later switched to OKT3 in the late 1980s and early 1990s.[10] Neither of these induction agents are currently in use in clinical practice. Likewise, with maintenance immunosuppression, we used cyclosporine, azathioprine, and steroids until the early 1990s. Most of our patients were maintained on triple immunosuppressive medications with cyclosporine, azathioprine, and steroids as the standard of care. Our long-term standard cyclosporine trough goal was 50–100 ng/ml. Maintenance immunosuppression was adjusted based on transplant provider discretion when considering various factors including immunological risk and complications.

Surgical technique:

Surgical techniques have also evolved over time. During the study period of 1986–1993, the surgical technique primarily used for SPK included using a whole pancreaticoduodenal allograft, which has been previously described in detail.[11] Bladder drainage using a 7–10 cm portion of the duodenal segment, as first described by Nghiem and Corry, was used.[12]

Enteric Conversion:

Patients with significant urologic complications or metabolic acidosis underwent conversion from bladder drainage to enteric drainage. The technical aspects of this procedure were previously described in detail.[13] Data regarding the reason for conversion and timing of conversion post-transplant were collected.

Statistical analysis

Continuous data were compared using Student's *t*-test or the Wilcoxon rank-sum test, as appropriate, while categorical data were analyzed using Fisher's exact test or chi-square test. *P* values <0.05 were considered statistically significant. Risk factors associated with graft failure were studied using univariate and multivariate stepwise Cox regression analyses. All baseline characteristics in table 1 were examined for factors associations with prolonged pancreas graft survival, up to 25 years. As all patients with prolonged pancreas graft survival were Caucasian, the race was not included for analysis. All analyses were performed using the MedCalc Statistical Software version 16.4.3 (MedCalc Software bvba, Ostend, Belgium; https://www.medcalc.org; 2016).

Results

The study population (Table 1):

Of the 291 SPK performed at UW between 1986 and 1993, 39 (13.4%) had a functional pancreas allograft for at least 25 years at last follow up (Table 1). Eight patients during the study period and one before the study period (total N=9) had pancreas graft survival of more than 25 years but failed at last follow up and were therefore not included for the comparison. None of the baseline characteristics were significantly different between the prolonged pancreas graft survival of more than 25 years and functional at last follow up group (N=39), compared to those whose graft failed before 25 years (N=244). Of the patients with prolonged pancreas graft survival, 22 (56.4%) were male and all were Caucasian.

As of 10/31/2019, the end of the study period, 527 SPK recipients were actively followed at our UW transplant clinic. Of those, 39 (7.4%) had the same pancreas graft for more than 25 years. The indication for SPK in all patients (N=39) was long-standing diabetic nephropathy with 97.4% (N=38) of patients previously diagnosed with type 1 insulin-dependent diabetes mellitus. The mean age at the time of transplant was 34.9 ± 6.1 years. Seven (17.9%) of the recipients received MALG for induction, 32 (82.1%) received OKT3, and all of the recipients were sent home on triple maintenance immunosuppression medication with cyclosporine, azathioprine, and steroids.

The nine recipients who lost their pancreas graft after graft survival of more than 25 years had a mean graft survival of 26.7 ± 1.4 years. Six (12.5%) died with a functional pancreas graft after mean of 27.9 ± 2.5 years of SPK, while 3 (6.3%) resumed insulin after mean of 26.2 ± 1.1 years. Of the nine SPK recipients with a failed pancreas graft, six also had kidney allograft failure.

Variables associated with prolonged pancreas graft (Table 2):

In the univariate analysis, bladder drained pancreas was associated with a lower probability of prolonged pancreas graft survival. After adjustments in the multivariate analysis, bladder drained pancreas (HR: 0.52, 95% CI 0.32 to 0.85, p=0.01) was still associated with decreased probability of prolonged pancreas graft survival.

Post-transplant complications (Table 3):

We examined some of the major post-transplant complications such as biopsy-proven rejection, malignancy, amputation, need for enteric conversion, kidney graft failure, infectious complications, and development of the autoimmune disease. Four (10.3%) patients underwent pancreas biopsy and three (7.7%) had rejection. Twenty-six (66.7%) patients developed malignancy with the most common form being skin cancer (N=15, 57.7%); four (15.4%) patients developed post-transplant lymphoproliferative disorder (PTLD). Seven (26.9%) patients developed other malignancies including leukemia, breast, cervical, renal cell, penile, and bladder cancer. Six (17.9%) patients experienced ongoing vascular disease requiring amputation, which included below the knee (N=2, 33.3%), transmetatarsal (N=3, 33.3%), and toe amputation (N=2, 33.3%). The mean time to amputation post-transplant was 21.3 ± 10.8 years. Enteric conversion from bladder-drained pancreas was required in 27 (N=67.5%) patients, with the most common indications being hematuria and bleeding (N=11, 40.7%), bladder leak (N=8, 29.6%), and infection (N=6, 22.2%). Kidney graft failure occurred in 11 (28.2%) patients at a mean of 19.0 ± 10.8 years of post-SPK transplant. In all of these cases, the chronic rejection was the cause of failure. Ten (N=90.9%) patients who experienced kidney graft failure underwent re-transplant. Almost all patients (N=36, 92.3%) experienced an infectious complication with the most common infection being a urinary tract infection (UTI) (N=27, 75.0%). Three (7.7%) patients developed autoimmune disease post-transplant and all developed rheumatoid arthritis.

Diabetes-related complications (Table 4):

The long-term follow-up in this cohort is a unique opportunity to describe the progression of diabetes-related complications including retinopathy, peripheral neuropathy, gastroparesis, and blindness after post-SPK transplant (Table 3). All of the symptoms were based on the patient's description and documented by the provider. Half (N=20, 51.3%) of patients experienced pre-transplant retinopathy, which at last follow-up was found to be stable or improved in 19 (95.0%) patients. Three (7.7%) patients were declared legally blind in one or both eyes post-transplant. Thirteen (33.3%) patients were diagnosed with pre-transplant peripheral neuropathy, and all of these patients were found to have the stable or improved disease at last follow-up. Pre-transplant gastroparesis was identified in four (10.3%) patients and was reported to be stable or improved in three (75.0%) patients. Four (10.3%) patients developed recurrent diabetes mellitus, defined as a resumption to low-dose insulin or oral glycemic agents.

Findings at last follow up (Table 5):

The mean post-transplant follow-up time in patients with a functioning pancreas graft was 27.4 ± 1.9 years. Thirty-five (89.7%) patients required no medications for blood sugar control, and 4 (10.3%) patients maintained a functioning graft but required low-dose insulin or an oral agent to control blood sugar. The mean HgbA1c was at the high-end of normal at 5.6% ± 0.6, mean serum creatinine was 1.6 mg/dl ± 0.6, and mean eGFR was 45.9 ml/min/1.73m^2 ± 20.3. Mean weight gain from pre-transplant to current weight was 10.9 kg ± 16.9. All (N=39) patients resided at home but 10.3% (N=4) of patients required significant help in the activities of daily living. Of the patients who require daily assistance, one patient had poor mobility due to a cerebrovascular accident, another patient due to a recent myocardial infarction and two patients were legally blind in both eyes. The remaining 35 were independent, with 8 of them describing their lifestyles as very active.

All patients had at least one co-morbidity such as hypertension (N=38, 97.4%), hyperlipidemia (N=26, 66.7%), or coronary artery disease (N=11, 28.2%). Donor-specific antibody (DSA) was measured in 33 (84.6%) patients and found to be positive in 13 (33.3%) patients at last check. Twenty-four (61.5%) patients remain on a three-drug immunosuppression regimen with the most common combination being mycophenolic acid (MPA), calcineurin inhibitor (CNI), and steroids (N=14, 58.3%). Eight (33.3%) patients remain on their original immunosuppression regimen of azathioprine, CNI, and steroids. One-third of patients (N=13) are on a two-drug regimen, most commonly CNI and steroids (N=8, 61.5%). Two (5.2%) patients are on steroids alone.

Discussion

The large historical cohort presented here of 39 SPK recipients with a functional pancreas allograft for more than 25 years represents a unique opportunity to describe the long-term benefits and complications of an SPK transplant. With vigilance and close observation, recipients of pancreas grafts may have outstanding outcomes. Our report suggests that normalization of glucose control alone may not prevent secondary complications, as demonstrated by significant rates of hypertension, hyperlipidemia, and the need for lower extremity amputation. Additionally, immunosuppression-related complications including malignancy and infections were common. However, significant stabilization of diabetes-related complications such as retinopathy and peripheral neuropathy was demonstrated. Freedom from insulin injections, dialysis, and further disability secondary to diabetes mellitus are critical factors to consider when weighing the risks and benefits of SPK transplantation.

It is important to address the long-term benefits of pancreas graft function including both survival benefit and reduced long-term complications.[14] In a retrospective analysis of 1000 SPK transplants with 22-year follow up, Sollinger et al. demonstrate that transplantation of both pancreas and kidney results in superior long-term patient survival compared to all other treatment options for type 1 diabetic patients with nephropathy including deceased donor kidney transplant alone.[15] Additionally, lower-extremity amputation is a serious complication of diabetes and diabetic individuals who have undergone amputation are more likely to die than their counterparts who have not undergone amputation.[16] A review of 2.5

million patients admitted for diabetic foot ulcers in the US from 2001–2010 reported an amputation rate of 16.5%,[17] which is similar to the rate found in our SPK patient cohort of 17.9% over a prolonged period of 25 years. One contributing factor to diabetic ulcers and subsequent amputation is the development of peripheral neuropathy. An important finding presented here is the complete stabilization or improvement of peripheral neuropathy in this cohort. Our findings suggest that patients who undergo SPK transplant may be at a decreased lifetime risk of amputation and therefore decreased mortality, as a result of stabilized peripheral neuropathy and fewer diabetic ulcers. Lastly, diabetic retinopathy was identified in 51.3% (N=20) of SPK patients and was stabilized or improved in nearly all of these patients (95.0%, N=19). The incidence of blindness or progressive retinopathy was 17.4% (N=4) in our cohort over 25 years. In comparison, the observational study following the Diabetes Control and Complications Trial (DCCT) reported 39% of intensive diabetic therapy patients had a further progression of their retinopathy since the end of the initial study period (mean duration of diabetes 29 years).[18] This follow-up period in the DCCT was 18 years from the end of the study, which suggests that over a long period, SPK transplant may be able to more successfully stabilize diabetic retinopathy compared to years of intensive therapy. Of note, the mean HgbA1c in the DCCT cohort was 8.0% compared to 5.6% in our SPK cohort, which may suggest that the complete normalization of HgbA1c following SPK transplant is necessary in order to halt the progression of retinopathy and other complications.

As immunosuppression has evolved over the past 25 years, significant improvements in allograft rejection have been achieved. Only 3 (7.7%) patients were noted to have pancreas rejection in this cohort. Low pancreas rejection rates are potentially the result of appropriate immunosuppression regimens. Nearly 2/3 of patients in this cohort are on triple immunosuppression regimens. Other considerations that must be made in regards to immunosuppression are malignancy and infectious complication rates. Previous studies have demonstrated a 2–4-fold increased risk of cancer in solid organ transplant recipients, which is largely related to immunosuppression.[19,20] 26 (66.7%) patients experienced some type of malignancy in this cohort. Balancing the risk of rejection versus malignancy becomes particularly difficult with multiple transplanted organs and as recipients continue to live longer. Our group has recently reported similar data among kidney only recipients with prolonged kidney graft survival of more than 25 years[10]. We noticed SPK recipients with prolonged pancreas graft survival have a higher incidence of overall malignancy at 66.7%, compared to the 44% in kidney transplant recipients. Moreover, non-skin cancer was 11 of 39 (28%) in this cohort, compared to 10 of 112 (9%) among kidney only recipients, which could be due to rigorous induction and maintenance immunosuppressive medications used among SPK recipients. Balancing the risk of rejection versus malignancy becomes particularly difficult with multiple transplanted organs and as recipients continue to live longer. Therefore, further follow-up will be required before recommendations for long-term immunosuppression regimens in this specific population are able to be made.

Cardiovascular disease (CVD), infection, and malignancy are the leading causes of death in kidney transplant recipients, which ultimately leads to the most common cause of graft failure-- patient death.[21] As with kidney transplant alone, the major benefit of SPK is decreased mortality and increased quality of life.[15,22] Compared to the kidney

transplant alone, SPK recipients experience additional improvements in their sense of well-being, autonomy, and independence.[23,24] Due to improved surgical techniques, immunosuppression, donor and recipient selection, and graft surveillance, the half-life of SPK pancreas graft has improved to 14 years.[25] SPK is now considered as the definitive and optimal treatment option in an appropriate patient with type 1 DM.[22]

Some SPK transplant recipients maintain excellent graft function, and an SPK transplant with a functional pancreas graft for more than 25 years is a great success. However, it is important to consider the benefit of long-term graft function with the complications seen with long-term immunosuppression use. As the prevalence of hypertension and dyslipidemia are significantly higher in this patient population, likely due to long-term immunosuppression. Optimal management of these cardiovascular risk factors represents one strategy to prevent cardiovascular events in order to prolong graft survival long-term.[26] It is critical to manage CVD in these patients due to the fact that it is the most common cause of death in kidney transplant recipients despite recent efforts to increase awareness of CVD in this patient population.[27] Hypertension is prevalent in more than 70% of transplant recipients.[28] No randomized, controlled trials of anti-hypertensive drugs or optimal blood pressure goals in transplant recipients exist; however, pharmacological therapy along with non-pharmacological interventions, including weight reduction, exercise, and dietary sodium restriction, is recommended.[27] Dyslipidemia, known to be strongly associated with CVD, is a common side-effect seen with immunosuppression medications including corticosteroids, calcineurin inhibitors and mammalian target of rapamycin.[27] Clinical trials specific to transplant patients have shown that interventions have an impact on reducing cardiac events.[29] As a result, the Kidney Disease Outcomes Quality Initiative (KDOQI) recommends lipid testing in all transplant patients on a regular basis and after the adjustment of immunosuppressive medications.[30]

Our observations have the limitations inherent to this type of study. As a single-center study, it may not be possible to generalize our results to other centers. There was no diversity in the patient race. Due to the nature of the study with historical data, some transplant-related data was missing. The complications commonly seen in the cohort presented here are similar to those described in the seminal study by Sollinger et al., which described the medical and surgical complications in a series of 1,000 SPK transplant recipients.[15] Although complications such as infection, malignancy, and cardiovascular remain prevalent, SPK transplantation remains an important option for diabetic patients with ESRD as seen through the stabilization in diabetes-related complications, improvements in a patient's sense of well-being and independence, and importantly, patient survival. However, is still not possible to make definite conclusion based on this observational study, whether sustained insulin independence and full pancreas function for more than 25 years was protective against the secondary complications, as incidence of need for amputation, and other complications related to the prolonged use of immunosuppressive medication were higher in this population. We were also, not able to explicitly find what were the factors that lead to prolonged graft survival. We believe only randomized control trial among diabetic ESRD patient who had SPK transplant vs those who remain on insulin for a prolonged period of time would answer this question.

To the best of our knowledge, this study is the first of its kind from a single-center that describes SPK recipients. Our data provide not only important information on patients with prolonged pancreas graft survival and associated complications to the providers, but it also provides encouragement and positive reinforcement to newly transplanted recipients, patients on the waiting list, and those considering SPK transplant as a therapeutic option. In summary, as the number of pancreas transplant recipients with prolonged graft survival increases, health care providers should be aware of the management of complications associated with prolonged pancreas graft survival in this unique group of patients.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Abbreviations:

CNI	Calcineurin inhibitor
CSA	Cyclosporine
CVD	Cardiovascular disease
DCCT	Diabetes Control and Complications Trial
DM	Diabetes mellitus
DSA	Donor-specific antibody
ESRD	End-stage renal disease
KDOQI	Kidney disease outcomes quality initiative
MALG	Minnesota anti-lymphocyte globulinMPA, mycophenolic acid
PTLD	Post-transplant lymphoproliferative disorder
SPK	Simultaneous pancreas and kidney
UNOS	United Network of Organ Sharing
UW	University of Wisconsin-Madison
WiSARD	Wisconsin Allograft Recipient Database

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Table 1:

Study Population

SPK patient characteristics	Pancreas graft survival ≥ 25 years at last follow up	Pancreas graft survival <25 years at last follow up	p
Total number of patients	39	244	
Year of transplant (range)	1986–1993	1986–1993	
Mean age at transplant (years)	35.0 ± 6.1	35.4 ± 5.9	0.67
Male	22 (56.4%)	151 (61.8%)	0.51
Race:			0.49
Caucasian	39 (100%)	241 (98.7%)	
Bladder drained pancreas duct	38 (97.4%)	225 (92.2%)	0.24
Induction immunosuppressive medication			0.86
Minnesota anti-lymphocyte globulin (MALG)	7 (17.9%)	41 (16.8%)	
OKT3	32 (82%)	203 (83.1%)	
Pancreas graft outcomes:	All functional		
Death with functional graft		90 (36.7%)	
Resumption of moderate- to high-dose insulin		97 (39.6%)	
Graft removed		29 (11.8%)	
Other (Transferred to a different center, death with unknown pancreas graft function)		29 (11.8%)	
Mean pancreas graft survival at last follow up (years)	27.5 ± 1.9	9.8 ± 7.5	<0.001

Table 2:

Variables associated with prolonged pancreas graft survival

	Univariate analyses			Multivariate analyses		
Variables	**HR**	**P**	**95% CI of HR**	**HR**	**P**	**95% CI of HR**
Age at transplant/year	1.01	0.40	0.98 to 1.03	1.0	0.57	0.98 to 1.03
Male	1.07	0.58	0.82 to 1.41	1.05	0.70	0.80 to 1.38
Bladder drained pancreas	0.54	**0.01**	0.33 to 0.88	0.52	**0.01**	0.32 to 0.85
OKT3 vs MALG induction	0.74	0.09	0.53 to 1.05	0.71	0.054	0.51 to 1.01

Table 3:

Post-transplant complications in patients with a functioning graft.

Post-transplant complications	N=39 (%)
Total number of the recipient with pancreas biopsy	4 (10.3%)
Total number of the recipient with pancreas rejection	3 (7.7%)
Total number of recipients with malignancy	26 (66.7%)
Skin	15 (57.7%)
PTLD	4 (15.4%)
Other (leukemia, breast, cervical, renal cell, penile, bladder)	7 (26.9%)
Amputation of lower extremity:	6 (17.9%)
Below knee amputation	2 (33.3%)
Transmetatarsal amputation	2 (33.3%)
Toe amputation	2 (33.3%)
Mean time to amputation (years)	21.3 ± 10.8
Enteric conversion from the bladder-drained pancreas	27 (67.5%)
Mean interval to enteric conversion (years)	4.7 ± 5.2
Reason for enteric conversion	
Bladder leak	8 (29.6%)
Hematuria, bleeding	11 (40.7%)
Recurrent UTIs, urethritis	6 (22.2%)
Other	2 (7.4%)
Kidney graft failure	11 (28.2%)
Kidney re-transplant	10 (90.9%)
Average time to failure (years)	19.0 ± 10.8
Reason for kidney graft failure	
Chronic rejection	11 (100.0%)
Infectious complications	36 (92.3%)
UTI	27 (75.0%)
CMV, HSV	2 (5.6%)
Cellulitis	3 (8.3%)
Osteomyelitis	2 (5.6%)
Pneumonia	2 (5.6%)
Development of autoimmune disease post-transplant	3 (7.7%)
Rheumatoid arthritis	3 (100%)

Abbreviations: PTLD, post-traumatic lymphoproliferative disorder; UTI, urinary tract infection; CMV, cytomegalovirus; HSV, herpes simplex virus

Table 4.

Diabetes-related complications.

Diabetes-related complications	N=39
Retinopathy	20 (51.3%)
Stable	18 (90.0%)
Improved	1 (5.0%)
Progressive disease	1 (5.0%)
Peripheral neuropathy	13 (33.3%)
Stable	10 (76.9%)
Improved	3 (23.1%)
Progressive disease	0 (0%)
Gastroparesis	4 (10.3%)
Stable	1 (25.0%)
Improved	2 (50.0%)
Progressive disease	1 (25.0%)
Blindness	3 (7.7%)
Recurrent diabetes mellitus	4 (10.3%)

Table 5:

Findings at last follow-up.

Findings at last follow up	N=39
Mean post-transplant follow up (years)	27.4 ± 1.9
Pancreas graft outcomes	
Functional graft, not requiring medications	35 (89.7%)
On low-dose insulin or oral agent to control blood sugar	4 (10.3%)
Functionality	
Independent	35 (89.7%)
Dependent for activities of daily living	4 (10.3%)
Hypertension	38 (97.4%)
Hyperlipidemia	26 (66.7%)
Coronary artery disease	11 (28.2%)
DSA findings on last follow up	
Never tested	6 (15.4%)
Negative on last check:	20 (51.3%)
Positive on last check:	13 (33.3%)
Current immunosuppressive medications:	
Three drug regimen	24 (61.5%)
Aza + CNI + steroids	8 (33.3%)
MPA + CNI + steroids	14 (58.3%)
Aza + sirolimus + steroids	2 (8.3%)
Two drug regimen	13 (33.3%)
MPA + steroids	4 (30.8%)
CNI + steroids	8 (61.5%)
Aza + steroids	1 (7.7%)
One drug regimen	2 (5.2%)
Steroids	2 (100.0%)
Mean HgbA1c (%)	5.6 ± 0.6
Mean serum creatinine mg/dl (n=28)	1.6 ± 0.6
Mean eGFR (ml/min/1.73m^2)	45.9 ± 20.3
Average weight gain post-transplant (kg)	10.9 ± 16.9

Abbreviations: DSA, donor-specific antibody; Aza, azathioprine; CNI, calcineurin-inhibitor; MPA, mycophenolic acid