Low Rates of Short- and Long-term Graft Loss After Kidney-Pancreas Transplant From a Single Center

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Importance: Since the 1980s, pancreas transplant has become the most effective treatment strategy to restore euglycemia in patients with type 1 diabetes mellitus. However, technical complications and BK virus nephropathy continue to be important causes of early and late graft loss. These and other complications lead to cited 1- and 3-year graft survival rates of 74% and 67% (pancreas) and 81% and 73% (kidney).

Objective: To examine our center’s outcomes with pancreas-kidney transplant and early BK virus screening and treatment.

Design: Prospective study from August 2004 to January 2012.

Setting: University medical center.

Participants: Sixty-five patients with type 1 diabetes who underwent simultaneous kidney and pancreas, pancreas after kidney, or pancreas transplant alone at a single center.

Intervention: Pancreas transplant.

Main Outcome Measures: Pancreas and kidney survival; patient survival; and kidney loss due to BK virus nephropathy.

Results: Patient survival at 1, 3, and 5 years was 100%, 98.4%, and 98.4%, respectively. Of 2 early pancreatic allograft losses, 1 was due to thrombosis (1.6%). One- and 3-year pancreas graft survival rates were 95.4% and 92.3%; losses after more than 1 year were due to rejection. Kidney survival rates were 100% and 95.2% at 1 and 5 years; losses were due to nephropathy and noncompliance, with 1 death with function. BK virus incidence was 29.2%, with no graft losses due to BK infection.

Conclusions and Relevance: While pancreas transplant can be complicated by early graft loss, our results suggest that excellent outcomes at 5 years can be achieved. Posttransplant BK virus screening and treatment are essential tools to long-term success.


Diabetes mellitus is a chronic disease with both profound individual and socioeconomic burden. In 2007, the US health care costs attributed to diabetes exceeded $174 billion, an estimate expected to escalate with the increased longevity and growing prevalence in elderly and pediatric obese populations, respectively.1,2 More importantly, the deleterious effects of diabetes on individual health lead to an incalculable decline in quality of life via progressive multisystem complications. For patients with type 1 diabetes mellitus (T1DM), the benefits of intensive blood glucose control in delaying diabetic nephropathy, retinopathy, and neuropathy have been well established since the seminal Diabetes Control and Complications Trial.3 Yet despite advances in the pharmacologic management of T1DM, safe and physiologic exogenous insulin delivery remains difficult to achieve for many patients.

Pancreas transplant is a highly effective treatment strategy to restore long-term euglycemia and stabilize the multiorgan derangements caused by T1DM.4 The significantly improved quality of life, freedom from exogenous insulin, relief of life-threatening hypoglycemic episodes, and potential survival benefit have furthered transplant as an acceptable therapeutic option over the past 2 decades, albeit at the expense of lifelong immunosuppression.5 Accordingly, pancreas transplants are typically performed in patients with T1DM with end-stage renal disease requiring kidney transplant, thus obligating the use of immunosuppression. The timing of pancreas transplant is either simultaneous with kidney transplant (SPK), after kidney transplant (PAK), or performed alone (PTA), with operative decision making dependent on pa-
tient risk factors, kidney function, and organ donor availability.

In 1966, William Kelly performed the first simultaneous pancreas and kidney transplant at the University of Minnesota. Although technical refinement has improved the rate of surgical complications and graft failure since the 1980s, pancreas transplant is still associated with significantly higher rates of perioperative morbidity (estimated to be as high as 10%-15%) than other solid organ transplants. Early postoperative complications recognized to confer increased risk of graft loss include graft thrombosis, hemorrhage, pancreatitis, and enteral intestinal leak. In addition, recipient factors such as tobacco use, obesity, and cardiovascular and cerebrovascular disease compound the overall risk.

Importantly, polyomavirus-associated nephropathy, also known as BK virus nephropathy (BKVN), is well recognized as an important cause of kidney allograft dysfunction and loss in solitary renal transplant and kidney-pancreas transplant recipients (although it has not been reported to cause pancreas allograft dysfunction). Once BK virus is diagnosed, kidney graft loss has been reported to be as high as 45% at 6 months. In a prior study by Lipshutz et al, the rate of BKVN in SPK patients at a single center was found to be 6.6%. A similar report in the literature determined their institutional rate at 7.5%. With no reliably effective antiviral agents available, the treatment of BK virus infection and nephropathy remains poorly defined. Currently, the primary mode of intervention is reduction of maintenance immunosuppression. However, both protocols and success rates remain heterogeneous and require further study in SPK patients.

The purpose of the present study was to (1) report our short- and long-term results of allograft and patient survival of kidney-pancreas allograft recipients; (2) define the causes for allograft loss, both short and long term; and (3) report the incidence of BK virus infection in kidney-pancreas transplant recipients and prospectively determine the influence of immunosuppression withdrawal on the survival of both the kidney and pancreas allografts.

**PATIENTS AND DATA COLLECTION**

This study was approved by the Committee for Human Research at the University of California, Los Angeles (UCLA) (institutional review board 11-003148). All pancreas transplant operations (SPK, PAK, and PTA) and patients at UCLA from August 2004 to January 2012 were followed up to collect recipient, transplant, and posttransplant data.

**PRETRANSPLANT AND POSTTRANSPLANT CARDIOVASCULAR SCREENING**

All patients from August 2004 to January 2012 were evaluated by a UCLA transplant cardiologist and underwent preoperative cardiac stress testing. Further testing was performed for higher-risk candidates including those older than 45 years with 25 years of insulin dependence and smoking or cardiac history. After activation on the transplant list, pretransplant patients underwent repeated cardiac stress testing yearly until transplant.

**KIDNEY AND PANCREAS TRANSPLANT PROCEDURES**

Donor pancreata and kidneys were procured from young deceased donors without evidence of pancreatic or renal dysfunction. Donor selection, operative technique, and postoperative management were performed as previously described by Schnickel et al.

After discharge, patients were followed up closely as outpatients. Urine and blood screening were performed for BK virus routinely posttransplant and if detected, monthly laboratory evaluation was performed until resolution of viremia/viruria. Routine screening was also performed for cytomegalovirus and urinary tract infections.

**IMMUNOSUPPRESSION AND TREATMENT OF REJECTION**

Immunosuppression consisted of induction with antithymocyte globulin and methylprednisolone and maintenance with tacrolimus, mycophenolate mofetil, and prednisone. Tacrolimus, a calcineurin inhibitor, was initiated on postoperative day 2 unless there was evidence of delayed kidney allograft function. Tacrolimus levels of 12 to 14 ng/mL were maintained for the first 6 months, then 10 ng/mL from months 7 to 12, and then 9 ng/mL thereafter. In patients where BK viremia/viruria was detected, levels as low as 5 ng/mL were tolerated. Mycophenolate mofetil was started on postoperative day 6 at 500 mg twice a day and increased to 750 mg twice a day on the subsequent day. After completion of thymoglobulin induction, patients began predni- sone tapering from 20 to 5 mg daily over the first month. For patients exhibiting mild hyperglycemia, tacrolimus was changed to cyclosporine (n=3), with levels of 200 to 300 ng/mL for the first year and 100 to 200 ng/mL thereafter.

Renal and pancreas allograft function were monitored by levels of creatinine and blood glucose and amylase and lipase, respectively. Renal allograft biopsy was performed if creatinine was elevated 20% or more above baseline and pancreas biopsy was performed for unexplained amylase or lipase elevations and/or hyperglycemia. All rejection episodes were diagnosed by biopsy and treated with thymoglobulin and steroid taper. Patients who had an episode of rejection were never completely weaned from prednisone.

**BK VIRUS SCREENING AND IMMUNOSUPPRESSION WITHDRAWAL**

Screening for BK virus in urine and blood was performed by quantitative polymerase chain reaction assay. A lower limit of detection in urine was less than 5 copies/mL and blood was 625 copies/mL with a linear range of 625 to $6.25 \times 10^4$ copies/mL. If BK virus was detected, mycophenolate mofetil was withdrawn typically over 3 months with close surveillance of serum creatinine, amylase, and lipase levels.

**STATISTICS**

Multivariate logistic regression analysis to assess for independent predictors of BK virus was performed using SPSS version 19 (IBM SPSS).
Pancreas donor cause of brain death, No. | GSW/MCC/PVC head injury | MVC/MCC/PVC head injury | Anoxia | Aneurysm/ICH | Other CHI | Other
--- | --- | --- | --- | --- | --- | ---
Kidney | 22 | 22 | 8 | 5 | 8 | 
Pancreas | 22 | 8 | 5 | 8 | 

Cold ischemia time, h, mean (SD) [range] | Kidney | 6.42 (1.36) [4.44-14.04] | Pancreas | 8.43 (1.37) [5.09-14.54]

Sex, No. (%)
- F: 49 (75.4)
- M: 16 (24.6)

BMI, mean (SD) 23.8 (2.9)

Table. Renal and Pancreas Transplant Donor Demographics

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CHI, closed head injury; GSW, gunshot wound; ICH, intracerebral hemorrhage; MCC, motorcycle crash; MVC, motor vehicle crash; PVC, pedestrian-vehicle crash.

INFECTION AND THROMBOSIS PROPHYLAXIS

Routine infection prophylaxis was as follows: (1) Pneumocystis carinii pneumonia (PCP) prophylaxis: combined trimethoprim and sulfamethoxazole (Septra double strength) 4 times a day for 3 months (changed programwide to 12 months in 2010 after PCP outbreak); (2) fungal prophylaxis: fluconazole, 400 mg daily for 2 months; and (3) cytomegalovirus prophylaxis: valganciclovir hydrochloride, 900 mg daily for 3 to 6 months depending on risk profile.20 Selection of thrombosis prophylaxis was dependent on whether the transplant was an SPK, PAK, or PTA, as previously described.20

DEMOGRAPHICS AND PATIENT SURVIVAL

From August 2004 to January 2012, 65 patients with T1DM underwent pancreas transplant (50.7% female; mean [SD] age, 42.8 [7.5] years; mean [SD] body mass index, 26.0 [3.5] [calculated as weight in kilograms divided by height in meters squared]) and were prospectively followed up after undergoing SPK (n = 45), PAK (n = 19), or PTA (n = 1) transplant (Table). Mean (SD) follow-up was 1454 (728) days. Thirty-day and 1-year patient survival rates were 100%. Three-year, 5-year, and 7-year patient survival was 98.5% (Figure). In this series of 65 patients, there was only 1 death. The cause is unknown because the patient was lost to follow-up 2 years after PAK. Two patients developed severe PCP necessitating prolonged hospitalizations. One patient (male, Hispanic, developed PCP 2 years and 8 months after SPK) recovered and has maintained normal pancreatic and kidney allograft function. A second patient (male, African American, developed PCP 5 years after SPK) was treated with intravenous pentamidine isethionate because of a national shortage of intravenous trimethoprim/sulfamethoxazole at the time. Because of the toxicity of pentamidine to islets,21-23 the patient has continued to require long-acting insulin. Both patients are alive and active adults at this time.

KIDNEY ALLOGRAFT SURVIVAL AND INCIDENCE OF BK VIRUS INFECTION

Overall kidney allograft survival was 96.9% (2 losses) with a third censored for death with function. One-, 3-, and 5-year kidney allograft survival rates were 100% and 7-year survival was 98.5% (Figure). Both kidneys were lost in PAK recipients. One kidney (and pancreas) allograft lost function 4 years and 9 months after PAK (5 years and 8 months after kidney transplant) because of noncompliance with medications and development of cellular and humoral rejection. The second kidney was lost because of calcineurin inhibitor toxicity and chronic allograft nephropathy 5 years and 6 months after PAK (9 years after kidney transplant).

BK viruria was diagnosed in 29.2% (n = 19) of recipients. Three of these patients were the recipient of a PAK and 16 were recipients of an SPK; the single PTA recipient has not demonstrated BK viruria. BK viruria was diagnosed a mean (SD) 485 (378) days (range, 90-1465 days) after receiving a pancreas transplant. BK viremia was detected in 12.3% (n = 8) of recipients, all of whom had been previously diagnosed with BK viruria. One of these patients was a PAK recipient and 7 were recipients of an SPK. BK viremia was diagnosed a mean (SD) 482 (318) days (range, 86-947 days) after receiving a pancreas transplant. Neither of the patients who lost kidneys in this series (n = 2) demonstrated BK viremia or BK viruria.

Patients with BK were treated by weaning mycophenolate mofetil to 250 mg orally twice a day followed by discontinuation. No patients developed rejection dur-
Recent data, however, suggest there may be little cardiovascular complications from systemic insulin re-
tal venous drainage and the preservation of liver first pass
docrine drainage of insulin has also been a subject of con-
m methods such as duodenum to ileum, gastric antrum, or
tage with donor duodenum to jejunum, although other
today, the most popular method involves enteric drain-
exploration of different approaches, most notably do-
unique to pancreas transplant. Devastating complica-
tion of exocrine and endocrine drainage is a challenge
has led to further declines in viral load.

A multivariate logistic regression analysis was per-
formed to assess for independent predictors of BK virus. 
Variables included recipient age, ethnicity, and sex; do-
nor sex, blood type, and race; type of transplant (SPK vs
PAK vs PTA); and year of transplant. There were no vari-
ables that independently predicted BK virus in this re-
gression analysis. Known risk factors (ie, ureteral stent 
diabetes mellitus) were excluded because all patients had 
his history of diabetes mellitus and had a stent 
at the time of transplant.

PANCREAS ALLOGRAFT SURVIVAL

Overall pancreas allograft survival was 92.3% (5 losses).
All losses occurred in PAK recipients. Thirty-day and
1-year allograft survival rates were 96.9% and 95.4%, re-
spectively, while 3-year survival was 93.8% (Figure). Five-
and 7-year pancreas allograft survival rates were 92.3%.
One graft was lost in the first week posttransplant be-
cause of allograft thrombosis. Notably, no grafts were lost 
drom duodenal leaks or primary nonfunction. Further-
more, no pancreatic allograft rejection developed during
selected withdrawal of immunosuppression for BK
viruria/viremia.

DISCUSSION

Over the past 50 years, pancreas transplant has evolved
from an experimental procedure to a highly successful
therapeutic option for patients with T1DM with end-
stage renal disease. Improved surgical technique and more
effective immunosuppression have been key to the im-
proved rates of graft survival and mortality. However, un-
like with other solid organ transplants, pancreas trans-
plant continues to experience significant technical compli-
cations, with limited evidence-based medicine to help
guide definitive technique. Specifically, management
of exocrine and endocrine drainage is a challenge
unique to pancreas transplant. Devastating complica-
tions from early methods of exocrine drainage (pancre-
atic duct ligation, injections with polymers) prompted
exploration of different approaches, most notably do-
nor duodenum to bladder drainage initiated in the 1980s.
Today, the most popular method involves enteric drain-
age with donor duodenum to jejunum, although other
methods such as duodenum to ileum, gastric antrum, or
Roux-en-Y are still practiced. Portal vs systemic en-
docrine drainage of insulin has also been a subject of con-
troversy. Early evidence suggested that physiologic por-
tal venous drainage and the preservation of liver first pass
effect may improve graft survival and avoid potential car-
diovascular complications from systemic insulin re-
lease. Recent data, however, suggest there may be little
difference in outcomes between either group.

These challenges inherent to pancreas transplant have
portended the technical complications that remain prob-
lematic for graft survival in the first year. Between 1994
and 2003, the University of Minnesota reported their tech-
nical pancreatic graft loss at 13.1% in a series of more
than 900 transplants. Among the causes were graft
thrombosis, pancreatitis, leak, and bleeding. Our study
is one of the few to report both short- and long-term out-
comes and causes of allograft loss. From 2004 to 2012,
our patient survival rates at 1, 3, and 5 years were 100%,
98.4%, and 98.4%, respectively. To date, our kidney
allograft survival is 97% (2 losses) and pancreas allograft survival is 92.3% (5 losses). Only 1 pancreas graft was
lost in the immediate perioperative period from throm-
bosis; 2 were lost from infection and 2 from noncompli-
ance. No grafts were lost from leak or primary nonfunc-
tion. From 2010, the United Network for Organ Sharing
reports 1-, 3-, and 5-year patient survival rates of 94.7%,
90.7%, and 86.5%, respectively. Kidney and pancreas graft
survival rates at 1, 3, and 5 years were 92.2%, 84.7%, and
77.7% and 84.5%, 77.9%, and 71.3%, respectively.

In this series, we have shown that excellent short- and
long-term results can be produced despite being a rela-
tively low-volume center. We believe this is due to a single
experienced surgeon performing all cases and careful post-
operative monitoring. Although an inverse association
between hospital procedure volume and postoperative
patient outcome has been demonstrated for some adult
and pediatric solid organ transplant procedures, this has
not been studied for pancreas transplant. Specifically,
our study (average of 9-10 pancreas transplants per year)
does not demonstrate such a volume effect. Nota-
ably, all lost pancreas allografts occurred in PAK recipi-
ents, which is mirrored by national data, reflecting that
pancreatic graft function is considerably shorter in PAK
than SPK recipients. Despite these risks, we believe PAK
in a selected population can still confer benefit from gly-
cemic control.

BK virus nephropathy has been well studied in the
single-kidney transplant population but there remains a
paucity of data on the effects of BKVN and immunosup-
pression reduction in SPK and PAK recipients. It is known
that asymptomatic BK viruria normally precedes vire-
mia and subsequent active nephropathy. Detection of the
BK virus prior to the development of BKVN presents an
opportunity for preemptive treatment with early immu-
osuppression reduction. To our knowledge, this is the
first prospective study on BK viruria/viremia screening
and early immunosuppression reduction in SPK and PAK
recipients, with outcomes measured by long-term graft
survival and resolution of BK viruria/viremia. Several re-
matching case series have shown institutional rates of
BKVN in SPK patients to range from 2.9% to 6.2%, with
subsequent kidney allograft loss between 0% and
89%. The retrospective review by Lipschutz et al of
146 SPK recipients from 1996 to 2002 identified a
BKVN incidence of 6.6%, more than half of whom sub-
sequently had kidney allograft loss. Notably, no pan-
creas grafts were reported to be lost from BKVN in any
of these case series.

In 2004, we established a program for routine BK vi-
rus screening and early initiation of mycophenolate mofetil
withdrawal in all SPK and PAK recipients. Our results have shown a 0% incidence of BKVN and, subsequently, no kidney losses from BKVN. Furthermore, 62.5% and 40% of recipients who developed BK viremia and viruria, respectively, experienced resolution after treatment. These findings suggest that routine screening and early treatment of BK virus in SPK and PAK recipients can be a powerful tool to help prevent the potential development of BKVN and its devastating sequelae including kidney graft dysfunction, loss, or ureteral strictures.

Interestingly, our results showed a fairly high incidence of BK virus detection, 29.2% of patients were found to have viruria. Given that 80% to 90% of the population was seropositive for polyomavirus, this could represent the natural history of BK virus reactivation in the immunosuppressed population. Furthermore, while quantitative polymerase chain reaction is largely the tool used to detect BK viral DNA, other methods such as urine cytology and urine VP1 messenger RNA have also been used, which could attribute to variance in detected cases among institutions. A multivariate logistic regression analysis was performed and there were no independent risk factors that predicted for BK virus in our series. Also unexplained is the 5 times higher rate of BK virus detected in SPK vs PAK recipients. These results appear paradoxical in that PAK recipients at our institution receive a second course of antithymocyte induction and have higher levels of tacrolimus maintained long term. The reason for a predominance of these cases in SPK compared with PAK recipients remains unclear.

There are limitations to this study including its involvement with only a single center. Furthermore, the exclusion of recipients older than 55 years potentially avoids a subpopulation of patients with comorbid conditions that may lead to worse overall outcomes. Several possible explanations also exist for our high patient and graft survival. First, the majority of donors were young with low body mass index. Second, we meticulously perform the back table preparation to avoid bleeding during reperfusion and we consistently perform a 2-layered hand-sewn intestinal anastomosis, which to date has not led to an anastamotic leak. Third, all planned recipients are seen by our team cardiologist pretransplant and undergo necessary angiography prior to transplant. To date, there have been no postoperative myocardial infarctions in our recipient population. Finally, all recipients are followed up lifelong by 1 transplant surgeon, with careful BK surveillance and immunosuppression adjustment. We credit this close outpatient follow-up to achievement of the long-term outcomes obtained and prevention of kidney allograft loss by BKVN.

Our results show that pancreas transplant is a highly effective option for patients with T1DM with end-stage renal disease and can be performed safely with excellent outcomes. Screening for BK virus with early treatment in kidney-pancreas transplant recipients are important tools to help prevent BKVN and subsequent kidney graft loss and dysfunction. Future multicenter prospective trials will be valuable to determine the durability of these measures.

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