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Evaluation of Kidney Transplant Candidates: An Update in 2012

Cheguevara Afaneh and Choli Hartono

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1. Introduction

The first successful kidney transplant between identical twins at the Peter Bent Brigham Hospital took place in Boston on December 23, 1954. This momentous event ushered in the modern era of organ transplantation. Kidney transplantation is now considered a routine procedure and is the treatment of choice for suitable patients with end-stage renal disease (ESRD). In 2001, approximately 100000 patients were predicted to be on the kidney transplant waiting list by 2010 [1]. In 2012, the waiting list is fast approaching that predicted number. A successful transplant affords independence from and provides a survival advantage over dialysis treatment [2]. However, patients with ESRD reap the benefit of renal transplant invariably at the expense of potential morbidity and mortality. The requirement to fully assess the benefit and risk of transplant ultimately is in the best interest of the candidate. By thoroughly evaluating a transplant candidate, the transplant program anticipates potential complications that may arise during the perioperative period. Moreover, appropriate kidney organs are in short supply relative to patients on the wait-list supporting the need to screen and identify candidates who are not eligible.

In the United States of America (US), kidney transplant candidates may receive either a live-donor (LD) or deceased-donor (DD) kidney. Live-donor kidneys may come from biologically related relatives or completely unrelated altruistic individuals. Increased potency of immunosuppressive agents has decreased the risk of acute rejection enabling transplantation from unrelated LD and DD kidneys. Harvesting marginal kidneys from deceased donors is gaining acceptance in response to organ shortages due to an expanding recipient pool. Organ Procurement Transplantation Network/United Network for Organ Sharing (OPTN/UNOS) implemented a new allocation system (UNOS Policy 3.5) in October 2002 to reclassify DD and better define the marginal kidney donor [3]. In the new classification schema, expanded criteria donor (ECD) is defined by any DD over the age of 60 or if aged between 50 to 59 with the addition of at least two of the following three criteria: cerebrovascular accident as a cause

of death, history of hypertension, and terminal serum creatinine above 1.5 mg/dL. Standard criteria donors (SCD) are DDs who do not meet the criteria for ECD. SCD or ECD kidneys may be procured from donation after brain death (DBD) or donation after cardiac death (DCD) donors. Potential candidates should be made aware that transplantation of marginal kidneys from deceased donors may result in delayed graft function (DGF), defined as the need for dialysis during the first week after kidney transplant.

Kasiske et al. provided for the American Society of Transplantation (AST) an in-depth discussion and reviewed guidelines for evaluation of renal transplant candidates in 2001 [4]. The British and Canadian guidelines for kidney transplant evaluation as well as recent reviews by Bunnapradist et al. and Scandling are referenced in [5-8]. The transplant candidate should be aware of various short- and long-term considerations, as listed in Table 1. In this chapter, updates will be presented on key issues such as age for candidacy, cardiovascular risk, recurrent disease, malignancies, viral infections, endocrine issues, hematology considerations, dual organ transplants, and high-risk candidates. Table 2 lists the standard initial kidney transplant candidate evaluation at New York-Presbyterian/Weill Cornell Medical Center.

Topics of Discussion for the Kidney Transplant Candidate

Perioperative risk factors:
    - Cardiopulmonary reserve
    - Extent of vascular disease
    - Obesity
    - Patient specific comorbid conditions, i.e. type 1 diabetes mellitus, end-stage liver
      disease, human immunodeficiency virus, [see references 4-8]

Extent of histocompatibility and type of organ donor regarding short- and long-term outcomes
Availability and suitability of a living donor
Discuss the willingness to accept marginal donor kidneys, pediatric donors, and high-risk kidney donors
Reasonable expectations of deceased donor waitlist times
Financial considerations of life-long immunosuppression as well as adverse event costs

Lifelong Immunosuppression Risks
    - Infections
    - Malignancies, with a predominance of skin cancers

Need for lifelong follow-up with frequent regular blood testing
Risks of graft failure and death following transplantation at various time points

Table 1. Kidney Transplant Candidate Considerations

2. Age as a factor for transplant candidates

The ESRD population is graying and in comparison to a decade ago, transplant programs are wait listing more individuals who are greater than 65 years old [9-12]. What are some of

the concerns for transplanting an older ESRD patient? A senior recipient in his or her seventh and eighth decades of life has a natural lifespan that is shorter than a younger patient hence reducing the predicted life years gained after transplant. Trepidation for the senior recipient is also the issue of further shortening patient survival after transplant due to the increased risk of transplant-associated morbidity. Indeed, Veroux et al. [13] observed that in a single center study in Italy, elderly recipients older than 65 years of age had a worsened survival rate after renal transplants from older donors when compared to wait-listed candidates. However, the functional status of elderly patients deteriorated if they have ESRD and require dialysis treatment [14]. Data from the United States Renal Data System (USRDS) demonstrated that the life expectancy of a 75-year-old patient on dialysis is only a third of a similar aged individual not receiving dialysis [15]. The 1-year survival rate of an 80- to 84-year-old patient on dialysis is 63% based on data from the USRDS [16]. Because the waiting time may be an obstacle for older transplant candidates, they may elect to receive ECD kidneys with a shorter waiting time [17]. Realistically, to fully address whether dialysis or transplant is a better option for this age group, a randomized study will have to be performed. Short of that, we are able to gleaned new insights into transplantation of seniors from the Scientific Registry of Transplant Recipients (SRTR) database.

In a study by Rao et al. [18], using data from the SRTR, the mortality risk of 5667 patients with age greater than or equal to 70 years old and listed between January 1, 1990 to December 31, 2004 were analyzed. There were 4475 (79%) patients with age between 70 to 74 years old and 1192 (21%) patients with age above 75 years old. Of the 5667 wait-listed candidates, 2078 (36.7%) had received a DD transplant, 360 (6.4%) had received a LD transplant, 1849 (32.6%) were deceased before transplant, and 1380 (24.4%) had not received a transplant prior to the cut-off period for analysis in December 2005. A third of the DD transplants were from ECD kidneys. The authors observed that kidney transplantation in patients greater or equal to 70 years of age was associated with a 41% reduction in mortality risk when compared to similar patients on the wait list [18]. The survival benefit was statistically significant in patients carrying a primary diagnosis of hypertension or diabetes mellitus but not significant for patients with glomerulonephritis [18]. Compared to wait-listed individuals, recipients of ECD kidneys enjoyed a 25% reduction in the risk of death whereas recipients of LD kidneys had a 57% reduction in mortality risk [18]. Analysis of relative mortality risk demonstrated that the risk of death at 45 days after transplant was 2.26 fold the risk of wait-listed candidates with the mortality risk equalizing at day 125 after transplant [18].

Huang et al. using data from OPTN/UNOS, compared the outcomes of recipients older than 80 years of age with recipients in the 60 to 69 and 70 to 79 age groups [19]. The 80 years and older cohort had 199 recipients (median age of 81 years) and represented 0.6% of the entire elderly cohort (age greater or equal to 60 years) that was transplanted between 2000 and 2008 in the US. The 60 to 69 years group had 24877 recipients whereas the 70 to 79 years group had 6103 recipients. The use of induction agents such as IL-2 receptor antagonist, antithymocyte globulin, and alemtuzumab were similar in the 3 groups. The rate of DGF

Consultations
Nephrology consultation
Transplant Surgery consultation
Social Work evaluation
Nutritional assessment
Pharmacy screening
Laboratory Data
Laboratory evaluation: 1. Serum chemistry 2. Serum hematology 3. ABO blood group verification on two separate dates 4. Viral serologies 5. Histocompatibility testing 6. Tubuerculosis screening (Quantiferon Gold) if PPD unavailable 7. Additional testing may be indicated based on co-morbidities
Other Baseline Data
Radiographic evaluation: 1. Chest x-ray 2. Complete abdominal ultrasound 3. MRI or CT Brain in patients with Polycystic Kidney Disease 4. Further testing may be indicated based on co-morbidities Electrocardiogram (EKG)
Routine Screening
Routine health maintenance screening: 1. Colonoscopy after the age of 50 years, and repeated as deemed appropriate 2. Mammogram in female candidates after the age of 40 years, and repeated as deemed appropriate 3. Pap smear in female candidates after the age of 21 years, and repeated as deemed appropriate 4. Prostate specific antigen (PSA) in male candidates over the age of 50 years, and repeated as deemed appropriate
Referrals
Referral to specialists as indicated based on candidate co-morbidities including: 1. Cardiologist 2. Gastroenterologist 3. Hematologist 4. Urologist 5. Psychiatrist

Table 2. New York-Presbyterian/Weill Cornell Medical Center Evaluation

defined as the need for dialysis therapy during the first week after transplant was similar in the 3 groups. The authors observed no difference in the rate of acute rejection during the initial hospitalization or at 1 year [19]. In the analysis, 73% of transplant recipients in the 80 years and older group were alive at 2 years [19] exceeding the expectation of the 2-year survival rate of 44% for a dialysis patient aged 80 to 84 years according to the USRDS database [15]. The overall perioperative mortality risk at 30 days was low at 1.5% for the overall cohort of elderly patients with a trend towards a higher perioperative mortality rate at 2.5% for the aged 80 years and older cohort [19]. Among the 80 years and older cohort, death-censored graft failure did not occur more frequently and the mortality rates were similar for SCD or ECD transplant recipients [19]. When comparing the 3 cohorts of elderly recipients, no differences were observed in the proportion of cardiovascular (P=0.64), infectious (P=0.47), malignant (P=0.27) and cerebrovascular (P=0.89) causes of death [19].

The recommendation from the AST is to avoid setting a cut-off age limit for eligible senior renal transplant candidates without medical contraindications [4]. When evaluating elderly patients for renal transplant, attention should be focused on the early perioperative mortality risk from cardiovascular comorbidity. ECD kidneys should be considered and offered to this age group to potentially shorten the waiting period [17].

3. Cardiovascular risk factors

Patients with ESRD are at risk for cardiovascular disease with 50% of all mortality in this population attributable to cardiac complications [20]. A retrospective analysis of 1460 renal transplant recipients at a major transplant center from 2000 to 2009 was performed to assess preoperative cardiovascular risk [20]. Among 962 patients with complete records, 357 patients (37.1%) underwent coronary angiogram demonstrating coronary artery disease (CAD) in 212 patients (59.4%) [20].

Death with graft function (DWGF) was the most common reason for graft loss observed in 10.4% of 1317 kidney transplants performed at a single major transplant center from 1996 to 2006 [21]. Of the 318 graft failures identified over the study period, DWGF occurred in 138 recipients (43.4%) [21]. The causes of DWGF include cardiovascular at 28.2%, infections at 15.2%, malignancies at 13.8%, and others or unknown represented 42.8% respectively [21]. In recent years, the rising imbalance between wait-listed candidates and available organs for procurement has necessitated the use of once discarded organs such as ECD and DCD kidneys. The expanded use of ECD and DCD kidneys has increased the incidence of DGF when compared to SCD transplants. According to the SRTR, the incidence of DGF was 31.2% for ECD, 37.1% for DCD, and 21.6% for SCD kidney transplants [22]. Tapiawala et al. investigated the relationship between DGF and risk of DWGF using data from the USRDS [23]. An increased risk of DWGF was observed among kidney transplant recipients with DGF (relative hazard of 1.53; 95% confidence interval 1.45 to 1.63 for fully adjusted models). Cardiovascular causes of death were slightly more prevalent in patients with DGF [23].

Diabetes mellitus is the most common etiology cited for ESRD in the US and a large proportion of renal transplants are done in patients with diabetes mellitus [24]. Diabetes

mellitus confers a poor prognosis for survival after renal transplant in association with cardiovascular disease that is often present before transplantation [24]. Ramanathan et al. investigated the prevalence of silent CAD in 97 asymptomatic type 1 and 2 diabetic kidney and kidney-pancreas transplant candidates by analyzing their cardiac angiogram records [25]. The authors observed that 33% of type 1 and 48% of type 2 asymptomatic diabetic patients had significant lesions (greater than or equal to 70%) in one or more coronary vessels [25]. A Norwegian study by Witczak et al. [26] also showed a high incidence of significant CAD in 155 diabetic renal transplant candidates who underwent compulsory coronary angiogram testing. Among the 155 patients, 69 patients (45%) were found to have significant stenosis (greater than 50%) resulting in 39 patients (57%) who required revascularization [26].

Pulmonary hypertension is highly prevalent in patients with ESRD resulting in increased mortality [27]. Identification of pulmonary hypertension may impact early graft function in renal transplant recipients [28]. Zlotnick et al. analyzed the impact of pulmonary hypertension defined as pulmonary artery systolic pressure (PASP) of greater than or equal to 35 mmHg by echocardiographic measurements on DGF and slow graft function (serum creatinine of greater than 3 mg/dL on post-transplant day 5) [27]. The authors demonstrated that pulmonary hypertension was an independent risk factor for early graft function in DD kidney transplants. An increased incidence of early graft dysfunction from 11.7% to 56% (P=0.01) was seen in DD transplant recipients with pulmonary hypertension [27].

In summary, cardiovascular risk should be addressed when assessing renal transplant candidates. A wait-list conference convened in 2002 recommended annual cardiovascular surveillance for diabetic ESRD patients [29]. Asymptomatic patients with diabetes mellitus should undergo rigorous cardiac testing for CAD including coronary angiogram if noninvasive studies are suspicious for pathology. Efforts to optimize cardiovascular care should be afforded to candidates at risk for DGF if they are potential recipients of ECD and DCD kidneys. Pulmonary hypertension should also be identified and addressed for wait-listed individuals at risk for DGF.

4. Malignancies

Malignancy is the third most common cause of mortality after renal transplant [21]. The risk of cancer is increased in solid organ transplant recipients [30]. A recent report suggests that renal transplant tourism in older individuals may be associated with a higher risk of post-transplant malignancy [31]. Because immunosuppressive agents could negatively impact existing and contribute to the emergence of malignancy after transplant, examining transplant candidates for the presence of malignancy is an important aspect of pre-transplant evaluation. Common malignancies encountered in the dialysis population include cancer in the kidney, bladder, and thyroid [32]. The AST guideline for most cancer encountered in patients on the wait-list is to delay transplant for 2 years to ensure no recurrence and up to 5 years for some cancer with a high incidence of recurrence [see reference 4]. However, certain malignancies may not warrant a long wait time [4] and

should be evaluated on a case-by-case basis at the transplant center. Herein, updates to challenging malignancies during evaluation and after transplant will be presented.

Post-transplant lymphoproliferative disorder (PTLD) has an incidence of 1-2% in renal transplant recipients and occurs at a rate 20-fold higher than in the general population [33]. Sampaio et al. investigated the risk of PTLD using the OPTN/UNOS database [34]. Between 2000 and 2009 and among 137939 kidney transplant recipients, 913 developed PTLD. The authors found that Epstein-Barr virus (EBV) donor (D) and recipient (R) status impacted on the risk of PTLD. Specifically, EBV D+/R- when compared to D-/R- was associated with an increase in PTLD incidence of 35% and 42% in adult DD and LD renal transplants respectively [34]. A relationship between monoclonal gammopathy of undetermined significance (MGUS) and PTLD was observed in a recent single center retrospective study [35]. In the study, MGUS was defined as a serum M protein of less than 3.0 g/dL, bone marrow biopsy with less than 10% plasma cells, and the absence of end-organ involvement. Of 42 patients with MGUS, 23 were identified prior to kidney transplant. After a median follow-up of 8.5 years, 4 (17.4%) patients with pretransplant MGUS went on to develop 2 cases each of smoldering multiple myeloma and PTLD [35]. Of the 19 posttransplant MGUS cases, none developed multiple myeloma but 2 patients were found to have EBV-negative T cell lymphoproliferative disorders at 16 and 26 years after transplant [35]. The authors concluded that patients with MGUS, a common disease that occurs in 2% of the population under the age of 50 could safely receive a kidney transplant [35].

Transplant recipients have an increased risk of various skin malignancies such as squamous cell carcinoma, melanoma, and basal cell carcinoma [36]. Pretransplant melanoma is often a malignancy cited as needing a long recurrence-free waiting time [4]. A recent report from a melanoma collaborative working group provided guidance when evaluating a potential candidate with a history of melanoma for organ transplant [37]. The recommendation is for no wait time in candidates with a prior history of melanoma *in situ* [37]. The working group suggests that the risk of recurrence is lower in thin melanoma (Breslow depth < 1mm) without any clinical evidence of metastasis and warrants a waiting time of a minimum of 2 years [37]. A shorter wait time may be reasonable for melanoma depth of < 1 mm and a negative sentinel lymph node (SLN) biopsy. Candidates with melanoma depth of > 2 mm should delay transplant until after a 5-year recurrence-free waiting period [37]. Transplant may be contraindicated in potential renal transplant recipients with lymph node involvement or frank metastatic disease from melanoma [37]. The data is lacking for transplant patients with melanoma depth of > 1 mm and < 2mm with a negative SLN biopsy. However, since the prognosis of immunocompetent patients with melanoma depth of < 2mm is favorable, renal transplant candidates with similar melanoma thickness may be eligible for a 2-year waiting period prior to transplant [37].

5. Recurrent disease

In a recent large retrospective single center study, recurrent glomerulonephritis (GN) was the cause in approximately 15% of kidney allograft failure after censoring for death [21].

Recurrence of prominent GN in the allograft namely focal segmental glomerulosclerosis (FSGS) and membranoproliferative GN (MPGN) will be discussed in this section.

Idiopathic FSGS has a high rate of recurrence after renal transplant. The rate of recurrence is estimated at 30% to 50% for the first kidney transplant and as high as 100% in subsequent kidney transplants [38]. Recurrence of disease may emerge within hours to days after kidney transplant or months to years later. Known risk factors for recurrence are Caucasian or Hispanic recipients, history of bilateral native kidney nephrectomy, mesangial hypercellularity, young recipients, progression to ESRD within 3 years after the diagnosis of FSGS is made, retransplant after failed allograft from FSGS recurrence [38-39]. Genetic and acquired mutations have been reported in 15% of idiopathic FSGS affecting slit diaphragm proteins such as podocin (NPHS2), nephrin (NPHS1), α-actinin 4, CD2AP, and TRPC6 [40-41]. Recurrence of FSGS may occur in less than 10% of patients with mutations in NPHS2 and commercial testing for this mutation could help to define the risk for donors [42]. The USRDS data reported that living donor transplants do not increase the risk of graft loss in FSGS [43]. Krishnan N et al. also reported successful renal transplant between monozygotic twins [44]. Cibrik et al. estimated the risk for death-censored graft loss to be 1% per year in adult FSGS recipients of zero HLA mismatch live-donor kidney in comparison to 4.4% per year for FSGS recipients of zero HLA mismatch deceased-donor kidney [45]. Because FSGS recurrence may in some recipients be unavoidable, efforts should be made to educate both donors and recipients of the risk with frank discussions about early graft loss. The previous finding of a circulating factor (30 to 50 kDa glycoprotein) being responsible for FSGS recurrence supports the use of plasmapheresis to manage at risk patients with idiopathic FSGS before and after kidney transplants [46]. Recent studies by Wei et al. implicated circulating urokinase receptor (suPAR) as a causative factor for FSGS recurrence [47]. In their report, the presence of suPAR in the serum was predictive of FSGS recurrence after transplant and lowering serum suPAR by plasmapheresis was associated with clinical remission [47]. Nozu et al. and Pescovitz et al. described the first two successful cases utilizing rituximab in children with recurrent FSGS and subsequent PTLD [48-49]. Followup reports by other investigators demonstrated complete, partial, and no response to rituximab [reviewed in reference 50]. Rituximab appears to play a direct role by targeting podocytes in recurrent FSGS and inducing remission [51]. More studies are needed to clarify recurrent FSGS cases that will respond to rituximab.

MPGN is the most common cause of recurrent GN in renal transplant allografts [38]. Among the 3 subtypes of MPGN, MPGN type II is now known as dense deposit disease with recurrence occurring in as high as 100% of transplant candidates [38]. On examination via electron microscopy, Dense deposit disease (DDD) is manifested by a ribbon-like electron-dense deposition in the glomerular basement membrane. Patients with DDD tend to have a low serum C3 level and up to 80% has a circulating autoantibody to C3Bb known as C3 nephritic factor (C3Nef) [38]. Evaluation of potential transplant candidates with DDD should include a search for the type of complement dysregulation. This is accomplished by assessing factor H, I, and membrane cofactor protein levels [38]. Consideration should be given to providing fresh frozen plasma prior to and after kidney engraftment in DDD

patients with complement dysregulation [38]. Vivarelli et al. recently reported the use of eculizumab, an anti-C5 antibody on a young 17-year-old patient with DDD and positive C3Nef but normal levels of factor H and factor B. [52]. Eculizumab was administered approximately seven years after the disease onset with a baseline focal sclerosis documented prior to therapy at 40% of glomeruli. The authors reported a reduction in proteinuria and microhematuria following administration of eculizumab. Repeat biopsies at 18 months after therapy showed a decrease in dense deposits in the glomerular basement membrane albeit with progression of glomerular sclerosis and tubular atrophy [52]. The authors observed an increased in the proteinuria when eculizumab was stopped after 18 months [52]. Following resumption of eculizumab therapy, the patient again responded with a reduction in proteinuria and had a normal renal function and blood pressure despite a persistently low serum C3 levels   [52]. Daina et al. similarly reported a favorable clinical response to eculizumab in a young patient who had previously received rituximab for DDD [53]. Radhakrishnan et al. reported on the successful treatment of refractory MPGN type I in a 16-year-old girl using eculizumab [54]. In the kidney transplant arena, a recent report by McCaughan et al. described the successful use of eculizumab in a recipient with recurrent DDD [55]. The patient was a 29-year-old female with ESRD from DDD and she received a kidney transplant from her brother after requiring renal replacement therapy for 6 years. She received triple immunosuppression with tacrolimus, mycophenolate mofetil, and prednisone without any induction and her best serum creatinine was 0.9 mg/dL. A recurrence, which was confirmed by biopsy that showed cellular crescents and polymorphs in the glomeruli with endocapillary proliferation was noted at 4 weeks after transplant. The patient was given a course of methylprednisolone, plasmapheresis, and rituximab with progressive deterioration of renal function with a rise in serum creatinine to 4.93 mg/dL. After a second biopsy to confirm the diagnosis of DDD at 10 weeks after transplant, eculizumab was provided with a loading dose of 900mg for 2 doses given a week apart followed by a maintenance dose of 600mg given every 2 weeks. The authors observed an immediate response with a dramatic decline in serum creatinine and reduction in proteinuria during the first 2 weeks of eculizumab therapy [55].

In summary, MPGN and FSGS may recur at a high rate following kidney transplant. Although allograft outcome is typically poor following recurrence, new approaches to therapy described herein may improve allograft survival.

6. Infections

Encountering chronic viral infections in the prospective renal transplant candidate is not uncommon. Viral hepatitides may be a known comorbidity or newly diagnosed during the transplant evaluation process. Patients with failed kidney transplant due to polyomavirus type BK induced nephropathy may present for retransplant evaluation. Increasingly, HIV patients with ESRD are also being referred for renal transplant. A list of the most common infections of kidney transplant recipients in a chronological order following transplant are listed in Table 3. Guidelines on the medical evaluation of hepatitis B or C infections in

potential transplant candidates were reviewed in reference [4]. Herein, updates on the evaluation of BK virus or HIV infected transplant candidates will be discussed.

Perioperative Infections in the Recipient
Nosocomial Infections -Methicillin-resistant *Staphylococcus aureus* (MRSA) -Vancomycin-resistant *Enterococcus* (VRE) -Hospital acquired pneumonia (HAP) -*Clostridium difficile* -Central venous catheter-associated infections -Urinary catheter-associated infections
Candida
Aspergillus
Infections Post-Transplant (1 to 6 months)
Viral infections -CMV -HSV -Shingles (VZV) -HBV or HCV recurrence or new infection -BKV -Community acquired viral infections (adenovirus, parainfluenza, respiratory syncytial virus, metapneumovirus)
Opportunistic infections -*Pneumocystis carinii (jiroveci)* -*Listeria monocytogenes* -*Toxoplasma gondii* -*Mycoplasma tuberculosis* -*Nocardia* -*Strongyloides* -*Leishmania* -*Aspergillus*
Infections Post-Transplant (>6 months)
Community-acquired pneumonia (CAP) CMV BKV Urinary tract infections Colitis *Aspergillus* EBV (associated with PTLD)

BKV: BK (polyoma) virus, CMV: cytomegalovirus, EBV: Epstein-Barr virus, HBV: hepatitis B virus, HCV: hepatitis C virus, herpes virus, HSV: herpes simplex virus, PTLD: post-transplant lymphoproliferative disorder

Table 3. Infections in Kidney Transplant Donors and Recipients

A prospective nonrandomized multicenter trial was conducted on HIV-infected ESRD patients who underwent live- or deceased-donor renal transplantation at 19 US transplant centers [56]. Eligible participants had a CD4+ T-cell count of greater or equal to 200 per cubic millimeter and undetectable plasma HIV-1 RNA levels. Participants were on a stable regimen of HAART for 16 weeks prior to kidney transplant. A history of treated opportunistic infections with the exception of progressive multifocal leukoencephalopathy, chronic intestinal cryptosporidiosis, primary central nervous system lymphoma, and visceral Kaposi's sarcoma were permitted for participants in the trial. Patients with hepatitis B coinfection must demonstrate undetectable hepatitis B virus surface antigen whereas patients coinfected with hepatitis C were offered pretransplant interferon therapy if eligible. Patients with hepatitis B and C coinfection had to demonstrate an absence of liver cirrhosis by biopsy. Induction with interleukin-2 receptor blocker and/or antithymocyte globulin was provided at the discretion of the transplant center. Participants received calcineurin inhibitor (CNI) cyclosporine or tacrolimus, mycophenolate mofetil, and glucocorticoid for maintenance therapy. CNI was replaced by sirolimus in patients with CNI-related toxicity. Among the 150 participants who were enrolled between November 2003 and June 2009, 1 subject withdrew consent at 6 months whereas 53 subjects had completed at least 3 years of follow-up at the time of analysis. The authors observed that the 1 year and 3 years patient survival rates (±SD) (94.6±2.0% and 88.2±3.8%) as well as graft survival rates (90.4% and 73.7%) were similar to the SRTR database for all kidney transplant recipients during the study period [56]. Both univariate and multivariate proportional-hazards models showed an increased risk of graft loss that was associated with treatment of rejection and the use of antithymocyte globulin induction whereas transplant using living donor graft was protective [56]. Of concern, the allograft rejection rate was unexpectedly 2 to 3 fold higher in participants of the trial when compared to the SRTR rejection rate at 1-year. Furthermore, approximately half of the rejection episodes were steroid-resistant indicative of severe rejection. Also unexpected, the authors did not observe any progression of HIV disease in the trial in spite of the initial decrease in CD4+ T-cell count and that maintenance immunosuppression did not promote HIV viremia. Among the 150 participants, 57 required hospitalization for 140 reported infections during the trial with 60% of serious infections occurring during the first 6 months after transplant. Of note, 5 cases of BK nephropathy and no cases of PTLD were observed during the study. The authors concluded that kidney transplant is a safe alternative to dialysis therapy for a select group of HIV-infected ESRD patients [56].

With the current reliance on immunosuppression, BK virus nephropathy (BKVN) may affect up to 8% of kidney allografts [57]. The negative impact of persistent BK viremia following BKVN-induced allograft failure on retransplant is a concern during re-evaluation. Womer et al. reported successful preemptive retransplant in 2 patients with active BK viremia [58]. The first patient was a 20-year-old Asian female deceased-donor renal transplant recipient with ESRD due to FSGS. Within approximately 3 years after transplant, BKVN was diagnosed along with transplant rejection. Severe allograft dysfunction ensued with glomerular filtration rate (GFR) falling to 14 mL/min despite therapy using intravenous immunoglobulin (IVIG), intravenous cidofovir, and reduction in overall immunosuppression.

Preemptive live-donor renal transplant from a 6 antigen-mismatched biological sister was performed with simultaneous allograft nephrectomy. No induction therapy was provided and maintenance immunosuppression consisted of prednisone, mycophenolate mofetil, and rapamycin. The authors observed a decline in plasma BK virus levels by PCR from 26000 copies/mL prior to retransplantation to undetectable at 14 days after retransplant. Plasma BK viral level of 9300 copies/mL was detected at 5 months after retransplant but had disappeared at 8 months and 21 months post-retransplant. A serum creatinine of 1.1 mg/dL was reported during the 21-month followup visit. The second patient was a 29-year-old Caucasian female simultaneous kidney-pancreas transplant recipient. BKVN was diagnosed at approximately 4 years after transplant. Severe allograft dysfunction ensued with glomerular filtration rate (GFR) falling to 13 mL/min despite therapy with intravenous cidofovir and conversion of CNI from tacrolimus to cyclosporine. Preemptive live-donor renal transplant from a 1 haplotype-mismatched biological sister was performed with simultaneous allograft nephrectomy. Antithymocyte globulin induction therapy was provided and maintenance immunosuppression consisted of prednisone, mycophenolate mofetil, and cyclosporine. The authors observed a decline in plasma BK virus levels by PCR from 50000 copies/mL prior to retransplantation to undetectable at 5 days after retransplant. Plasma BK was detected at 12 months after retransplant. The short-term favorable outcome in the case-reports by Womer et al. supports early retransplant of patients following BKVN-associated allograft failure. Consideration should be given to simultaneous graft nephrectomy during retransplant.

7. Familial renal disease

Autosomal dominant polycystic kidney disease (ADPKD) is often encountered in transplant candidates presenting with a family history of renal disease and ESRD. The requirement and optimal timing of kidney nephrectomy may pose a dilemma for the prospective patient, referring physicians, and transplant center. Skauby et al. retrospectively analyzed their single center live-donor transplant experience comparing the outcome of a consecutive series of 159 kidney transplant recipients with ADPKD [59]. After excluding 2 patients with insufficient data, 157 patients were divided into 2 groups of ADPKD patients. Group A (n=79) received live-donor kidney transplant alone whereas group B (n=78) underwent simultaneous bilateral nephrectomy (SBN) and live-donor kidney transplant. The authors observed a higher rate of intraoperative complications in group B with significantly longer operative time, a higher requirement for blood transfusion, and need for plasma products. Two patients from group B required dialysis in comparison to non in group A. However, graft survival rates at 1 year and 5 years were similar in groups A and B at 94.8% and 89.6% versus 96.1% and 90.8%, respectively. Patient survival up to 5 years was also similar between the 2 groups. Based on their study, the authors advocated the following decision algorithm. The choice to undergo SBN is dependent on the patient's personal opinion, residual renal function, presence of mass effect, propensity for renal infections, and suspicion for malignancy. When nephrectomy of native kidneys is necessary and a live donor is available, kidney transplant with SBN may be preemptively performed. In the event that plasmapheresis or anticoagulation is required during the perioperative period

and nephrectomy of native kidneys is deemed necessary, bilateral nephrectomy is performed prior to the transplant.

Alport's syndrome is an X-linked disease causing ESRD and affecting predominantly male patients. Transplant candidates should be made aware of the uncommon (less than 5%) development of anti-glomerular basement membrane (anti-GBM) disease after kidney transplant. Anti-GBM disease in allograft presents as crescentic glomerulonephritis with linear fixing of IgG and C3 to the glomerular basement membrane and usually induces graft loss. Retransplant of candidates with Alport's syndrome and failed allografts due to anti-GBM disease remains challenging. Despite plasmapheresis and appropriate anti-T cell therapy, Browne et al. showed that graft loss remained unavoidable in patients with Alport posttransplant anti-GBM disease [60].

8. Hematology considerations

Blood transfusion is often necessary in the perioperative period especially in transplant recipients at risk for bleeding. Preemptive transplant candidates may also present with profound anemia due to advance uremia or lack of erythropoietin replacement therapy. Scornik et al. investigated the contribution of posttransplant blood transfusion to development of human leukocyte antigen (HLA) antibodies in 746 patients transplanted over a 6-year period [61]. Data on solid-phase HLA antibody testing was available in 199 patients. Blood transfusion was provided to 45% of the cohort and approximately 80% of the transfusion was given during the first month after transplant. The authors observed that the frequency of *de novo* antibodies was 16% in the 199 patients tested. Only 1 person developed anti-HLA antibodies in a group of 12 patients who had required transfusion of greater than 10 red cell units. In the study, non donor-specific anti-HLA antibodies were not induced by blood transfusion. Within the limitation of a single center retrospective analysis, the authors concluded that unlike pretransplant transfusion, blood transfusion in the posttransplant setting did not sensitize transplant recipients [61].

9. Endocrine considerations

Overweight is defined as a body mass index (BMI) of greater than or equal to 25 kg/m^2 whereas obesity is defined as a BMI of greater than or equal to 30 kg/m^2 [62]. Concurrent with an epidemic of obesity in the general population of developed and developing countries, the prevalence of obesity has also increased in kidney transplant candidates in recent years [63]. Severely obese transplant candidates are at risk for perioperative complications such as poor wound healing and DGF. Weissenbacher et al. retrospectively analyzed their single center data on 1132 deceased-donor transplant between 2000 and 2009 [64]. The DGF rate was 32.4% in the entire cohort. Multivariate analyses showed that BMI and dialysis vintage were independent risk factors for DGF. The authors demonstrated that the incidence of DGF was increased in obese recipients with BMI over 30 kg/m^2 at 52.6% (P<0.0001) when compared to non-obese kidney transplant recipients [64]. The DGF rate was 25.2%, 29.8%, and 40.9% for recipients with BMI of less than 18.5 kg/m^2, 18.5 to 24.9 kg/m^2,

and 25 to 29.9 kg/m^2 respectively. In the study, DGF resulted in poor 1- and 5-year graft and patient survival.

In general, prospective transplant candidates with obesity should be referred to a transplant dietician for counseling. Eckel has reviewed the treatment option for obesity in the general population [62]. Alexander et al. studied gastric bypass procedure (GBP) in thirty morbidly obese patients who had chronic renal failure and kidney transplants [65]. Of the 30 patients, 19 patients had chronic kidney disease (12 were already on dialysis), 8 patients had GBP after kidney transplant, and 3 patients had kidney transplant following GBP. The authors observed that reduction in BMI in excess above 25 kg/m^2 at 1, 2, and 3 years after GBP was similar with or without transplantation. The reduction of BMI in excess above 25 kg/m^2 was around 70% at 1 year for the various cohorts. Among the 30 patients, only 1 had serious wound infection after removal of sutures and no other complications related to the GBP were reported. Further studies are needed in the ESRD population to determine a safe strategy for managing obesity while patients are on the transplant wait-list. Morbidly obese transplant candidates who are recalcitrant to diet and exercise may require surgical interventions to lose weight.

10. High-risk candidates

Additional preoperative preparations are warranted for high-risk transplant candidates who are predisposed to perioperative graft dysfunction (Table 4). Herein, three different clinical scenarios will be discussed that may impact early graft function and require special attention before transplant.

High-Risk Category	Treatment Options
Presensitized & highly sensitized candidate	1. Desensitization protocols including plasmapheresis, IVIG, and/or Rituximab 2. Kidney-paired donation (if living donor available) 3. Utilization of marginal donor kidneys 4. Utilization of pediatric donor kidneys
Hypercoagulable Conditions	1. Correct underlying disorder if possible 2. Begin anticoagulation perioperatively with/without heparin bridge and warfarin 3. Consider preoperative inferior vena cava filter
Chronic low blood pressure	1. Consider mineralcorticoid administration 2. Maintain aggressive volume resuscitation 3. Consider postoperative anticoagulation 4. Consider vasopressor administration

Table 4. High-Risk Kidney Transplant Candidates

Evaluation of a prospective transplant candidate with respect to the blood type and determining HLA compatibility as well as confirming a negative donor crossmatch are minimum requirements to assess the immunologic risk prior to kidney transplantation.

Crossing the ABO blood type barrier as well as transplanting highly sensitized patients with anti-donor HLA antibodies may result in hyperacute or accelerated early rejection. Hence, at the present time, transplanting an ABO incompatible or complement-dependent cytotoxicity (CDC) crossmatch positive kidney should not be undertaken without prior "desensitization". Determination of ABO compatibility between the donor and recipient is easily accomplished but must be rigorously enforced in the clinic. Characterizing a sensitized prospective transplant candidate is more complicated with recent advancement beyond the routine CDC crossmatch method to detect subtle class I and class II anti-donor HLA antibodies. Contemporary crossmatch techniques involve the use of flow cytometry-based principle to detect anti-HLA antibodies. Together with ELISA-based method, flow-cytometry, and single antigen fluorescent bead (SAFB) or Luminex platform represent new solid-phase assays in determining the degree of sensitization in the transplant candidate. These techniques have been previously reviewed [66-67]. Contrary to desensitization in the field of allergy, "desensitization" in transplantation refers to the procedure of reducing anti-donor HLA antibodies prior to engraftment. Specific protocols to desensitize patients are beyond the scope of this chapter but have been extensively published in the literature. Most centers utilize a combination of plasmapheresis, IVIG, and rituximab to desensitize and prepare patients with significant immunologic risk [68-69].

The next at-risk ESRD population going into kidney transplantation to be discussed are those predisposed to thrombosis of the allograft in the early posttransplant period. Determination of transplant candidates with thrombophilia starts with obtaining a history for hypercoagulopathy. Laboratory studies for Factor V Leiden, protein C and S, lupus anticoagulant (LA) antibodies, anticardiolipin antibodies (aCL) and anti-β_2-glycoprotein I antibodies (anti-β_2GPI) may further inform the risk of thrombosis. Antiphospholipid syndrome (APLS) is a common cause of acquired thrombophilia characterized by the presence of antiphospholipid antibodies (APA). Canaud et al. recently demonstrated the negative impact of APA in kidney transplants recipients [70]. Of a cohort of 37 patients with APA, 12 met the diagnostic criteria for APLS at the time of transplant. Of the 12 patients with APA positive APLS, 4 died early after transplant. Compared to control, patients with positive APA had more frequent early graft thrombosis and deep venous thrombosis (27% vs. 7%, $P<0.05$ and 35% vs. 14%, $P<0.05$ respectively). The authors observed that APA positive patients also had a more rapid decline in GFR at 1 year after transplant [70].

Another high-risk group of transplant candidates have consistently low blood pressure heading into the transplant procedure. Webber et al. investigated the role of low blood pressure from 993 kidney transplant recipients between 2003 and 2008. They showed using a case-control study design that an average mean arterial pressure less than or equal to 80 mmHg during the 3 months prior to kidney transplantation is a risk factor for primary nonfunction of the allograft [71].

11. Dual organ transplantation

Kidney transplantation may be performed concurrently with other solid organs such as liver, heart, and pancreas. According to the OPTN/SRTR 2006 annual report, the rate of

combined pancreas-kidney transplants has remained steady over a five-year period since 2001. In contrast, multiorgan transplants involving liver-kidney and heart-kidney have substantially increased [72]. Considerations given to potential candidates for pancreas and liver transplants are listed in Table 5. Herein, evaluation of potential candidates for simultaneous pancreas-kidney as well as liver-kidney transplantation will be discussed.

An estimated 23000 pancreas transplants had been performed worldwide since the procedure was introduced four decades ago by Dr. Richard Lillehei [73]. Recently, the Centers for Medicare and Medicaid Services (CMS) approved and will cover pancreas transplant alone (PTA) procedure done on or after April 26, 2006 [72]. Patients with ESRD and insulin-dependent type I diabetes mellitus may benefit from simultaneous pancreas-kidney (SPK) or pancreas after kidney (PAK) transplantation. Because the waiting time depending on local variance may be substantial, approximately half of the wait-listed SPK candidates may die if not transplanted within 4 years of listing [74]. Therefore, if a live kidney donor is available, PAK should be considered in suitable prospective SPK candidates. In 2005, the number of active candidates on the SPK waiting list was approximately 1500 whereas it was approximately 330 for the PAK list [72]. The eligibility guidelines for pancreas transplantation were reviewed in reference [75]. The presence of insulin therapy is required and documentation of a lack of endogenous insulin production is accomplished by checking C-peptide level. A reasonably young age is one of the criteria for pancreas transplant. We reviewed our single center data on greater than 50-year-old pancreas transplant recipients and found them to also be feasible candidates [76]. Further studies are needed to establish if a strict age limit should be enforced on prospective pancreas transplant candidates. Potential pancreas transplant candidates should be evaluated for coronary artery disease (CAD) with consideration for coronary angiogram in patients with significant CAD risk factors such as smoking, presence of hypertension, and presence of peripheral arterial occlusive disease. Diabetic complications such as retinopathy, peripheral and autonomic neuropathy, microangiopathy and macroangiopathy, as well as life-threatening metabolic syndrome such as hypoglycemic unawareness must be documented during evaluation. Prospective candidate should be informed of the benefits of achieving euglycemia via pancreas transplant. The beneficial effects of pancreas transplant on retinopathy, neuropathy, nephropathy, vasculopathy, and quality of life were reviewed in reference [75]. In addition, candidates must be made aware of the 10-year survival advantage after SPK over DD kidney transplant alone (65% versus 46% respectively) [77]. For candidates awaiting pancreas transplants on the PAK list, renal allograft function should be adequate with creatinine clearance generally well above 40 mL/min. Studies investigating the risk of developing diabetes mellitus after successful pancreas transplant may provide insights into the optimal preoperative selection of pancreas transplant candidates. Dean et al. examined the outcome of 144 pancreas transplants from their center between 2001 and 2005 [78]. Posttransplant diabetes mellitus (PTDM) was diagnosed in 28 patients (19.4%) over the study period and developed at a median time of 87 days after pancreas engraftment. The presence of endogenous insulin secretion was confirmed by measuring C-peptide when PTDM was diagnosed. Of the 28 patients with PTDM, 26 became insulin dependent whereas 2 received oral hypoglycemic agents. The authors

observed when comparing the PTDM group to those who did not develop diabetes mellitus that age at transplant, pretransplant hemoglobin A1c, prednisone doses or tacrolimus concentrations were similar. However, patients in the PTDM group had a higher median pretransplant BMI (29 vs. 24 kg/m²), higher pretransplant median daily insulin requirement (69 vs. 40 units per day), higher mix of pretransplant type II diabetes mellitus (45% vs. 17%), and increased incidence of acute rejection. The authors concluded that PTDM could occur in pancreas transplant recipients despite documentation of a functioning pancreas allograft in patients with increased pretransplant BMI, elevated pretransplant insulin requirement, and increased acute pancreas rejection episodes.

Pancreas Transplant Candidate Considerations
Extent of complications of type 1 diabetes mellitus
Assess/optimize preoperative body mass index (BMI)
Review total daily insulin requirement
Previous transplants (i.e. potential locations suitable for placement of pancreas allograft)
Baseline blood pressure (chronic hypotension increases risk of pancreas allograft thrombosis)
Hypercoagulable conditions (lupus anticoagulant, anticardiolipin antibodies, anti-β2-glycoprotein I antibodies)
Availability of a living donor for kidney transplantation
Liver Transplant Candidate Considerations
Presence of hepatorenal syndrome as cause of end-stage renal disease
Intrinsic renal disease
Renal replacement therapy dependence for >8 weeks
Model of End-stage Liver Disease (MELD) score
Hepatitis B & C virus specific considerations
Cardiovascular preoperative assessment
Rule out underlying preoperative infections
Nutritional status preoperatively (liver transplant associated with high morbidity)

Table 5. Dual Organ Transplant Considerations

The model of end-stage liver disease (MELD) was instituted on February 27, 2002. Increasingly, simultaneous liver-kidney transplants (SLK) are performed in more orthotopic liver transplant (OLT) candidates since the introduction of the MELD system [79]. In 2001, 134 recipients of SLK transplants were recorded by the SRTR. By 2007 the number of SLK transplant recipients had increased to 444 [79]. Eason et al. reviewed the SRTR database up to 2007 and identified that the MELD scores during listing and at transplant were 24 and 25 respectively for SLK candidates not on dialysis whereas for candidates on dialysis they were 27 and 31 respectively [79]. Data from SRTR between the year 2002 to 2005 showed that the unadjusted waiting list survival for SLK candidates on dialysis fared worst when compared to liver transplant alone (LTA) candidates with or without dialysis and SLK candidates not on dialysis [79]. Davis et al. recommended an algorithm when evaluating OLT candidates for possible SLK [80]. Assessment of renal function based on urinalysis, serum creatinine,

and spot urine protein to creatinine as well as albumin to creatinine ratios and 24-hour urine analysis should be the initial steps taken during evaluation. Abnormal findings during the evaluation warrant further assessment based on imaging studies, kidney biopsy, and serological analysis. The key element to distinguish when evaluating potential SLK candidates is the presence of acute kidney injury (AKI) versus chronic kidney disease (CKD). Pichler investigated the etiology of renal insufficiency or persistent hepatorenal syndrome (HRS) greater than 4 weeks in 26 OLT candidates [81]. The authors observed 6 cases of MPGN, 5 cases of IgA nephropathy, 4 cases of AKI, 4 cases of focal global glomerulosclerosis, 3 cases of diabetic nephropathy, and 4 cases of normal histology [81]. Wadei et al. investigated the feasibility, value, and risk of percutaneous kidney biopsy on 44 OLT candidates with GFR of less than 40 mL/min/1.73m^2 or on renal replacement therapy [82]. Of the 44 subjects, 13 had acute tubular necrosis (ATN), 5 had MPGN, 11 had minimal findings, and 15 had advance interstitial fibrosis (≥30%)/glomerulosclerosis (≥40%) (IF/GS). Of the 15 patients with IF/GS detected on kidney biopsy, 14 candidates were listed for SLK, 1 patient was deemed not a suitable candidate for transplant. Twenty-seven patients who were listed for LTA had renal biopsy findings that showed ATN (3 cases), MPGN (2 cases), IF/GS (1 case), and minimal findings (11 cases). The biopsy complication rate in the study was 30% with 8 major complications and 5 minor complications. Seven of the 8 major complications consisted of retroperitoneal hematoma and gross hematuria, which required selective coil embolization in 5 patients. The authors reported no mortality or surgical intervention related to the biopsy [82]. Participants of a consensus conference on SLK recommended that SLK should be offered to cirrhotic patients with ESRD and symptomatic portal hypertension or hepatic vein wedge pressure gradient of ≥10 mmHg, liver failure and CKD with GFR ≤30 mL/min, AKI or HRS with serum creatinine ≥2.0 mg/dL and renal replacement therapy for ≥8 weeks, liver failure and renal biopsy showing >30% GS or IF [79].

12. Retransplant considerations

An increasingly number of candidates on the waiting list represent failed kidney transplant patients who have been recycled. These patients are potentially sensitized from their previous transplants and have unique issues to be considered during re-evaluation.

Retransplant candidates may present after a long-term history of graft function or a brief period of functioning kidney graft. It is important to determine the etiology of transplant failure especially if a prior kidney transplant biopsy is available for examination. Cases whereby recurrent disease is responsible for graft failure often presents a challenge to the candidate and the transplant center. Goldfarb-Rumyantzev et al. analyzed the USRDS database to gain insight into the role of preemptive retransplant and subsequent graft and patient outcome [83]. A total of 92844 pediatric and adult kidney transplant patients were identified between 1990 and 1999 with the follow-up period captured through end of 2000. The authors analyzed 11714 recipients who had a single retransplant during the study period. Of the 11714 recipients, 1609 received a preemptive retransplant whereas 10,105 were recipients of non-preemptive retransplant. Consistent with current findings in the clinic, the study had a high proportion of DD in recipients of non-preemptive retransplant.

The authors showed that the risk of graft failure was higher in preemptive retransplant by 36% but did not impact on recipient survival [83]. The study also revealed that prolonged prior graft survival was protective on successive patient and graft survival.

Failed kidney transplants in patients with ESRD contribute to increased morbidity and mortality [84]. The role of graft nephrectomy may pose as a clinical dilemma in early and late kidney transplant failure, which occurs less than or greater than 12 months after engraftment. The benefit of removal of a nonfunctional kidney must be weighed against the risk of sensitization especially if preemptive retransplant is being considered. Johnston et al. investigated the impact of graft nephrectomy on repeat transplant [85]. The retrospective analysis was performed utilizing USRDS database including transplants from 1995 to 2003 and preemptive repeat kidney transplants were excluded. Of the 19107 patients included in the study, 6213 patients underwent a nephrectomy whereas 12894 patients were without nephrectomy. The authors observed that transplant nephrectomy was frequently performed and twice as common in early versus late graft failure. Transplant nephrectomy appeared to be protective in patients with late graft failure but was associated with an increased risk of death in patients with early graft loss. However, nephrectomy in late graft loss was associated with an increased risk of retransplant failure whereas it was protective in patients with early graft loss. Interpretation of the study was limited by a lack of information on the indication for nephrectomy and the retrospective nature of the analysis. Marrari et al. studied the contribution of graft nephrectomy to the development of donor-specific HLA antibodies [86]. A total of 16 international histocompatibility laboratories contributed 65 cases for analysis. The authors found that the incidence of DSA reactivity determined by Luminex assay prior to and after nephrectomy was 64% vs. 87% (p=0.0033) for HLA-A,B mismatch category and 57% vs. 86% (p=0.001) for HLA-DRB1 mismatch category. The frequencies of individual reactive antigens pre- and post-nephrectomy was 49% vs. 75% (p<0.0001) for HLA-A,B mismatch category and 48% vs. 79% (p=0.0001) for HLA-DRB1 mismatch category. In contrast, the frequencies of DSA to DRB3/4/5 (65% vs. 78%, p=0.22) and DQ mismatches (76% vs 87%, p=0.18) were not significantly different before and after graft nephrectomy.

13. Conclusions

The deceased-donor kidney transplant wait-list in the US has grown from a 15000 patient list in 1990 to an approximately 55000 patient list in 2002 and is now approaching a 100000 patient list in 2012 [29]. The waiting time continues to increase since the annual transplant rate has not kept pace. In the US, only approximately 16000 kidney transplants were performed in 2009 [87]. Maintaining oversight of the ever-expanding waiting list with careful timely review of candidates is an important task for the transplant center. Because ESRD patients are at risk for cardiac events while on the waiting list, to reduce posttransplant complications, it is imperative that cardiac surveillance is updated in a timely manner. For the high-risk diabetic patient, cardiac evaluation may have to be updated on an annual basis. Prospective candidates on the list who are suitable should be identified and educated on the benefits of ECD kidney transplant. In conclusion, transplant evaluation is

an important process for the transplant center to distinguish suitable candidates from ineligible ESRD patients. The goal is to anticipate and minimize posttransplant complications and to prolong kidney allograft survival.

Author details

Cheguevara Afaneh
Department of Surgery, New York Presbyterian Hospital-Weill Cornell Medical Center, New York, NY, USA

Choli Hartono
The Rogosin Institute, New York, NY, USA
Division of Nephrology and Hypertension, Department of Medicine, New York Presbyterian Hospital-Weill Cornell Medical Center, New York, NY, USA
Department of Transplantation Medicine, New York Presbyterian Hospital-Weill Cornell Medical Center, New York, NY, USA

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