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Original Article

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BK Virus Infections in Pediatric Kidney Transplant Recipients: A Single-Center Experience

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ABSRACT

Objective: BK virus infections and associated nephropathy are important causes of morbidity in kidney transplantation. This study aimed to evaluate the incidence, clinical, and outcome characteristics of BK virus infections among pediatric kidney transplant recipients followed up at a tertiary center.

Methods: Among 66 patients who received kidney transplants between January 2011 and January 2022, 12 patients with BK virus viruria and/or viremia were retrospectively analyzed using medical records and an institutional transplant registry.

Results: The incidence of BK virus viremia and/or viruria was calculated as 18% and BK virus infections and associated nephropathy was 13.6%. The median age at the time of transplantation was 13 years (interquartile range 10.1-14.8) and from transplantation to BK virus detection was 11 months (interquartile range 3.2-50.2). Median serum creatinine levels at the time of BK virus viremia were 0.9 mg/dL (interquartile range 0.8-1.2), median glomerular filtration rate 79.5 mL/min/1.73 m^2 (interquartile range 59.5-101.2). Kidney biopsy was performed in all patients and showed BK virus infections and associated nephropathy in 9 (75%). In all patients rmycophenolate mofetil was either reduced or stopped and in 67% steroid doses were reduced. Mycophenolate mofetil was switched to sirolimus and tacrolimus to cyclosporin-A in 92% and 16.6% of the patients, respectively. Ciprofloxacin was used in 92%, intravenous immunoglobulin 83%, cidofovir 75%, and leflunomide 58% of the patients. Median follow-up was 38.5 (interquartile range 28-84.2) months and the median estimated glomerular filtration rate at the last visit was 56 mL/min/1.73 m^2 (interquartile range 48-80.5). There was no significant difference between baseline and follow-up estimated glomerular filtration rate levels ($P = 0.146$).

Conclusion: Although BK virus may cause devastating complications. Routine monitoring and prompt intervention, mainly immunoreduction, may prevent graft loss.

Keywords: BK virus, children, immunosuppression, kidney transplant, nephropathy

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INTRODUCTION

Recent advances in immunosuppression have not only increased allograft survival but also infection rates which is one of the most important problems post-transplantation.[1] BK virus (BKV), a double-stranded, non-enveloped DNA virus from the Polyomaviridae family, deserves special attention among these infections. It is quite prevalent in the general population with a seroprevalence up to 90% in young adults.[2,3] In childhood, BKV is mostly asymptomatic, remains latent in the urinary epithelium, and does not cause any problems in healthy individuals. It can be reactivated when the immune system is suppressed, such as in kidney transplantation, and may lead to viruria, viremia, nephropathy, and graft loss.[4]

In 2007, the incidence of BKV-associated nephropathy (BKVAN) in pediatric kidney transplant recipients was found as 5% in the first 2 years post-transplantation and related graft loss 24%.[5] Recent publications have shown increasing rates: 18%-37% for BKV viremia and up to

16% for BKVAN which is quite high when compared to 10%-20% vs 2%-8%, respectively, in the adult population.[6-10]

The exact causes of BKV infections are unknown. With the introduction of strong immunosuppressive agents like tacrolimus and mycophenolate mofetil (MMF), the incidence of BKVAN increased which supported the hypothesis that immunosuppression plays a role in the pathogenesis.[6] Pediatric data indicated that young recipient age, cytomegalovirus (CMV) seronegativity of the recipient, strong immunosuppression, cadaveric donor, tacrolimus (more frequently than with cyclosporin A-CSA), and obstructive uropathy as a primary renal disease were BKV risk factors.[6,11,12]

Current knowledge on BKV-related post-transplant problems is limited and studies are very rare in the pediatric age group. With this study, we aimed to retrospectively investigate the seroprevalence, clinical and laboratory features, treatment modalities, and prognosis of BKV infection in pediatric kidney transplant recipients followed up at our center.

METHODS

Sixty-six pediatric patients who underwent kidney transplantation between January 2011 and January 2022 were retrospectively evaluated using medical records and an institutional transplant registry system. Twelve patients with BKV viruria, viremia, and/or nephropathy followed up for at least 12 months were included. Patient demographics; transplantation date; immunosuppression protocols; date of BKV detection; kidney function tests; proteinuria; serum tacrolimus, CSA, sirolimus levels at the time of BKV detection, 6th and 12th months post-BKV and last available visit; kidney biopsy results and treatments used for BKV were recorded.

Routine immunosuppression protocol for pediatric kidney transplantation at our center consists of anti-IL2 treatment (basiliximab omitted in cases with complete human leukocyte antigen (HLA) matching), steroids, calcineurin inhibitors (tacrolimus most commonly), and MMF.

BK virus screening is routinely performed at 1, 3, 6, 12, and 24 months after transplantation and when serum creatinine levels increased more than 10% above the baseline. Viruria was diagnosed when BKV was detected greater than 10^7 copies/mL in the urine by polymerase chain reaction (PCR). Viremia was defined by PCR when BKV DNA load was greater than 10^4 copies/mL in the blood. Ongoing BK viremia more than 3 weeks was considered suggestive of BKVAN.[11] Kidney biopsy was performed when there was no improvement in viremia despite treatment or when impairment in kidney functions persisted. BK nephropathy was diagnosed by BKV-specific cytopathic changes and immunohistochemical staining with SV40 antibodies in kidney biopsy.

BK virus treatment strategies were made at the discretion of the attending physician but were generally homogeneous. The first step was the reduction in immunosuppression tailored to patient's clinical condition. Steroid dose reductions were made to hold the dose below 10 mg/day. Mycophenolate mofetil was first reduced to 25% of its original and in a stepwise approach stopped per needed or switching to sirolimus was performed. Dose reduction for tacrolimus was done by 25%-50% and tacrolimus was replaced with CSA when needed. For patients receiving CSA, the target serum drug level was determined as 100-150 ng/mL and for sirolimus or tacrolimus below 6 ng/mL. For resistant BKV cases in various combinations, cidofovir (1 mg/kg/week), ciprofloxacin (20-30 mg/kg/day), leflunomide (10 mg/day for children weighing 10-20 kg, 15 mg/day for 20-40 kg, 20 mg/day for over 40 kgs), and intravenous immunoglobulin (IvIg) (0.2-2 g/kg) were used. Two weeks after any change in the treatment, BKV was screened again. Serum creatinine was measured by traditional Jaffe reaction and the estimated glomerular filtration rate (eGFR) was calculated by using the original Schwartz formula.[13]

Statistical Analysis

Data analyses were performed by using Statistical Package for Social Sciences (SPSS) Version 21.0 (IBM Corporation, Armonk, NYC, NY, USA). Samples were tested with Shapiro–Wilk test to determine the normality of distributions.

According to the results, non-parametric tests were preferred. Continuous variables were compared by Mann–Whitney *U* test and categorical variables by chi-square or Fisher's exact test as appropriate. A *P*-value of <.05 was considered statistically significant. The interquartile range (IQR) was reported as 25th-75th percentiles.

The study was approved by the institutional Ethics Committee of Hacettepe University (Approval no: GO22/620, Date: 21.06.2022).

RESULTS

The study included 12 patients (11 with BKV viruria, 10 with viremia, 8 with both viremia and viruria). Among them 9 patients (6

MAIN POINTS

- BK virus associated nephropathy may cause graft loss in kidney transplant recipients and studies in the pediatric population are rare.
- The risk factors for BK virus associated nephropathy are not well-defined; young age at the time of transplantation, intense immunosuppression, rejections episodes, congenital anomalies of the kidney and ureter as the underlying disease are among the accused causes.
- There is neither consensus on the management nor any proven antiviral therapy. Treatment strategies mainly rely on reduced immunosuppression to boost the host immune system for limiting the virus.
- With routine BK virus screening by PCR in plasma and/or urine and early intervention better allograft survival is possible.

males, 3 females) had biopsy confirmed BKVAN. The incidence of BKV viremia/viruria in our center was calculated as 18% (12/66) and BKVAN 13.6% (9/66).

At the time of transplantation, median age of the 12 patients was 13 (IQR 10.1-14.8) years. Nine patients received their allografts from living donors. Important clinical and laboratory characteristics of the patients are given in Table 1.

The median time from transplantation to BKV detection was 11 (IQR 3.2-50.2) months and 50% (6/12) of the patients were within their first year of transplantation. There were 4 patients who experienced BKV infection after 2 years of transplantation.

At the time of BKV detection, median serum BK levels were 108 685 copies/mL (IQR 36707-2999236). BK viremia was detected in 2 patients by screening protocol whereas 10 patients showed an increase in serum creatinine levels. Median serum creatinine levels at the time of BKV viremia were 0.9 (IQR 0.8-1.28) mg/dL, median GFR 79.5 (IQR 59.5-101) mL/min/1.73 m^2, and median proteinuria 6.1 (IQR 3.9-8.6) mg/m^2/h.

Table 1. Baseline Characteristics of the Patients

Patient Characteristic	Total Number of Cases (n = 12)
Sex, Male, n (%)	9 (75%)
No of cadaveric donors	3 (25%)
Etiology of end-stage kidney disease, n (%)	
CAKUT	5 (41.7%)
Glomerulopathy	4 (33.3%)
Tubulopathy	1 (8.3%)
Cystic kidney disease	1 (8.3%)
aHUS	1 (8.3%)
First transplant, n (%)	12 (100%)
HLA mismatch, n (%)	
1/6	1 (8.3%)
2/6	3 (25%)
3/6	5 (41.7%)
4/6	1 (8.3%)
5/6	2 (16.7%)
Previous dialysis history, n (%)	11 (92%)
Previous immunosuppression history, n (%)	5 (42%)
Recipient EBV IgG seropositivity	11 (91.6%)
Recipient CMV IgG seropositivity	11 (91.6%)

aHUS, atypical hemolytic uremic syndrome; CAKUT, congenital anomalies of the kidney and urinary tract; CMV, cytomegalovirus; EBV, Epstein–Barr virus; HLA: human leukocyte antigen.

Kidney biopsy was performed in all patients, in 8 patients, more than 1 kidney biopsy was needed. Biopsy results showed BKVAN in 9 patients. In 4 BKVAN patients, Tubulointerstitial nephritiswas diagnosed in biopsies performed at different time points of follow-up. In 2 patients, despite BK viremia and impaired kidney functions, biopsy showed no signs of BKVAN. Among BKVAN patients who underwent biopsy due to increased serum creatinine levels, 2 patients had no significant viremia.

Among patients diagnosed with BKV, serum tacrolimus levels were within the expected ranges in all but one patient who had serum tacrolimus levels of 8.6 mg/dL in his second year. Drug doses used were within the reference ranges in all patients.

None of the patients experienced any surgical complications like lymphocele after transplantation. Data on the duration of ureteral stent use werenot available.

Co-infection with other viruses was present in 2 patients. One patient had a concomitant parvovirus infection when BKV was detected. The other patient with focal segmental glomerulosclerosis and Schimke immunoosseos dysplasia had CMV infection which was treated with gancyclovir successfully.

During follow-up, 10 patients (5 with BKVAN) experienced biopsy-proven rejection episodes (6 acute T-cell, 6 acute borderline T-cell, 3 chronic T-cell, 2 acute B-cell mediated). Three patients had rejection episodes before, and 1 patient had rejection at the same time with a BKVAN diagnosis. Among 5 patients with BKVAN after a median of 8.5 months (IQR 5.75-18), rejections were diagnosed, and in none of them, increment in BKV serum titers after rejection treatment was observed. Co-occurrence of rejection with BKVAN was observed (patient number 9); in the fourth month after transplantation, T-cell-mediated rejection and BKVAN in the same biopsy occurred. While treating this patient based on the intense BKV staining in the biopsy and high serum BKV titers, MMF doses were reduced and cidofovir was used. After close follow-up, a decrease in BKV titers and renal improvement were seen.

The initial treatment strategy was immunoreduction in all patients. In 8 (67%) patients, steroid doses were reduced. Reduction and/or cessation of MMF was performed in all (100%) patients. Mycophenolate mofetil was switched to sirolimus in 11 (92%) and tacrolimus was replaced with CSA in 2 (16.6%) patients. Cessation of tacrolimus was performed in 7 patients. There was only 1 patient who was followed up with immunoreduction only and did not require further treatments for BKV. Ciprofloxacin was used in 11 (92%), IvIg in 10 (83%), cidofovir in 9 (75%), and leflunomide in 7 (58%) patients. Table 2 shows important baseline and follow-up features of the patients.

Table 2. Baseline and Outcome Characteristics of Patients with BKV

Patient No	Type of Donor	Induction Treatment	Maintenance Treatment	Acute Rejection	BKV Detection after Transplantation (mo)	Clearance of BK Viremia after Detection (mo)	Serum Tacrolimus Level at BKV Detection (ng/mL)	Treatments Used	eGFR at BKV Detection (mL/min/1.73 m^2)	eGFR at Last Visit	eGFR Decrement during Follow-up (%)
1	Living	Basiliximab	Tac + MMF + steroids	None	30	41	4.7	Steroid dose reduction MMF →, mTORi switch Tac discontinuation Cidofovir Ivig Ciprofloxacin	90	55	38%
2	Living	Basiliximab	CSA + MMF + steroids	T cell	57	none	N/A	MMF dose reduction, mTORi	108	73	32%
3	Living	None	Tac + MMF + steroids	T cell	5	1	6	Steroid dose reduction MMF→, mTORi switch Tac discontinuation, Leflunomide Ivig Ciprofloxacin	47	48	N/A
4	Living	Basiliximab	Tac + MMF+ steroids	None	3	None	7,5	Steroid dose reduction MMF→, mTORi switch Tac discontinuation Leflunomide Cidofovir Ivig Ciprofloxacin	75	17	77%
5	Living	Basiliximab	Tac + MMF + steroids	T cell	74	None	8.6	MMF→, mTORi switch Tac discontinuation Leflunomide Cidofovir Ivig Ciprofloxacin	84	55	34%
6	Cadaveric	Basiliximab	Tac + MMF + steroids	B cell	14	N/A	5	Steroid dose reduction MMF→, mTORi switch Tac discontinuation Cidofovir Ivig Ciprofloxacin	84	72	14%

(*Continued*)

Table 2. Baseline and Outcome Characteristics of Patients with BKV (*Continued*)

Patient No	Type of Donor	Induction Treatment	Maintenance Treatment	Acute Rejection	BKV Detection after Transplantation (mo)	Clearance of BK Viremia after Detection (mo)	Serum Tacrolimus Level at BKV Detection (ng/mL)	Treatments Used	eGFR at BKV Detection (mL/min/1.73 m²)	eGFR at Last Visit	eGFR Decrement during Follow-up (%)
7	Cadaveric	Polyclonal antibodies	Tac + MMF + steroids	Borderline T cell	2	None	10.6	MMF→, mTORi switch Tac discontinuation Cidofovir Ivig Ciprofloxacin Leflunamide	109	147	N/A
8	Cadaveric	Basiliximab	Tac + MMF + steroids	T, B cell	8	15	8	Steroid dose reduction MMF→, mTORi switch Tac discontinuation Cidofovir Ivig Ciprofloxacin	105	83	21%
9	Living	Basiliximab	Tac + MMF + steroids	T cell	4	None	7,2	Steroid dose reduction MMF→, mTORi switch Tac discontinuation Cidofovir Ivig Ciprofloxacin Leflunamide	72	57	21%
10	Living	Basiliximab	Tac + MMF + steroids	T cell	16	1	5.7	Steroid dose reduction MMF→, mTORi switch Tac discontinuation Ivig Ciprofloxacin	41	48	N/A
11	Living	Basiliximab	Tac + MMF + steroids	T cell	61	None	5.6	Tac → CSA switch MMF→, mTORi switch Ivig Cidofovir Ciprofloxacin Leflunamide	59	33	44%
12	Living	None	Tac + MMF + steroids	None	2	2	5.5	Steroid dose reduction Tac→ CSA switch MMF→, mTORi switch Cidofovir Ciprofloxacin Leflunamide	61	87	N/A

CSA, cyclosporin A; eGFR, estimated glomerular filtration rate; MMF, mycophenolate mofetil; mTORi, mammalian target of rapamycin inhibitor; N/A, not applicable; Tac, Tacrolimus.

Median follow-up of the patients was 38.5 (IQR 28-84.2) months. At last visit, serum BKV was below significant levels in 5 patients which occurred at a median of 9 months (IQR 2.2-34.5) after the first detection of BKV. Median serum creatinine at the last visit was 1.4 mg/dL (IQR 1-1.67). Median eGFR at last visit was 56 mL/min/1.73 m^2 (IQR 48-80.5) and proteinuria was 8 mg/m^2/h (IQR 2.6-21). There was no significant difference in baseline and follow-up eGFR and proteinuria levels (P = .146 and 0.433, respectively). There was only 1 patient who had an eGFR of 17 mL/min/1.73 m^2 at the last visit (patient no 4) (Table 2).

DISCUSSION

This study showed a BKVAN rate of 13.6% in our center and emphasized that immunoreduction alone was not sufficient in the majority. The low percentage of graft loss in our patient population indicated the importance of screening, early detection, and treatment for BKV in preventing unwanted complications.

Currently, BKV is among the feared infectious agents in renal allograft recipients. There has been evidence for its increasing rates from 4.6% of BKVAN in 2007 to 20.3% (presumptive and biopsy-proven BKVAN) reported by the CERTAIN registry in 2019.[5,11] In different pediatric studies, BKV infection rates ranged between 26% and 36% and graft loss was reported between 7% and 24% despite treatment efforts.[6,10,12]

BK virus infection may have different clinical presentations like hemorrhagic cystitis, ureteral stenosis, and interstitial nephritis.[14] Its reactivation is usually asymptomatic but when BKVAN develops, kidney functions begin to deteriorate.[15] In our cohort, 10 patients showed an increase in serum creatinine levels. Interestingly, in 2 patients BK viremia was detected incidentally, without an increase in serum creatinine. In one of these patients, BKVAN never developed, and in the other patient, 7 months after a rejection episode at the 54th month posttransplant, BKVAN was detected and managed properly, which we believe highlighted the importance of screening and prompt management.

It is recommended to routinely screen all kidney transplant recipients in the first 2 years for BKV in the blood and/or urine and newer guidelines suggest to use only serum screening due to its high specificity.[16] Viral loads over 10^4 copies/mL in the plasma (100% sensitivity, 99% specificity) and 10^7 copies in the urine (100% sensitivity, 95.5% specificity) detected by PCR are cutoff values for the diagnosis.[8,14] In 2009, Kidney Disease Improving Global Outcomes (KDIGO) recommended serum BKV screening at least monthly in the first 6 months, then every 3 months till the end of the first year after transplantation. They suggested immunoreduction when BKV values remain over 10^4 copies/mL.[17] Our BKV follow-up protocol consists of routine serum and urine BKV PCR screening at 1st-, 3rd-, 6th-,12th-,18th-, 24th-month posttransplant, when there is an unexplained elevation in serum creatinine levels.

Definite diagnosis of BKVAN is made by biopsy.[18] Kidney biopsy indications generally consist of graft dysfunction, high immunological risk, and sustained BK viremia.[7] Histologically, viral cytopathic changes like nuclear enlargements and basophilic viral inclusions affecting the tubule epithelium are typical.[19] Tubular damage and concomitant interstitial inflammation may be seen. Persistent BKVAN results in parenchymal scarring, progressive tubule atrophy, and interstitial fibrosis. The presence of BKV in the tissue is demonstrated by immunohistochemical staining and cross-reaction of antibodies developed against the large T antigen of Simian virus 40 with BKV and is pathognomonic for BKV replication.[20] In our cohort, all patients underwent biopsy, and in 9 patients, BKVAN was detected. In 4 of the BKVAN patients who underwent multiple biopsies, TIN was diagnosed at different time points.

For BKV-related disease, various risk factors have been accused. Underlying disease is one of the suspected etiologies. Höcker et al[11] found obstructive uropathy to be an independent risk factor for BKVAN with an unknown mechanism. Similarly Patel et al[21] reported vesicoureteral reflux or obstructive uropathies in 24% of the patients with BKV-related graft loss. Since the virus resides in the uroepithelium; it can be speculated that ureter–bladder pathologies might increase the risk of BKV reactivation; however, further studies are needed for better clarification. In our cohort, most of the patients were within congenital anomalies of the kidney and ureter (CAKUT) spectrum with 3 posterior urethral valve cases. Young age at transplantation was found to be significantly associated with BKV viruria and viremia which might be explained by the fact that most children are naïve to this virus.[11] Other known risk factors reported are cadaveric donors, CMV seronegativity, and high level of immunosuppression.[6,12,15] In accordance, 50% of our patients were within their first year of transplantation receiving high doses of immunosuppression and most a had history of rejection episodes; however, a trend of increment in serum BKV titers after rejections was not observed. McCaffrey et al[6] reported a period of median of 295 days post-transplant for the first detection of BK viremia which might be explained by the high immunosuppression during the first year. Accordingly, we found a median time of 11 (IQR 3.2-50.2) months. Human leukocyte antigen mismatch and BKVAN association have not been widely studied in the pediatric population. Patel et al reported that high HLA mismatch rates were significantly associated with BKVAN-related graft failure.[21] They speculated it originated from increased rejection risk and intense immunosuppression used. Similarly, in our study, 10 patients experienced rejection episodes 80% of whom had ≥3/6 mismatch rates.

Treatment strategies for BKV have always been a matter of debate. The most widely used approach is to reduce immunosuppression and monitor BKV levels in serum and urine by PCR, while balancing the risk of acute rejection. Reduction in immunosuppression is aimed to reboost the host immune system to limit BKV replication. Studies showed that after the reduction

of immunosuppression in 80%-100% of patients, serum viral load and BKVAN risk were decreased.[1,7,10] Replacement or dose reduction of calcineurin inhibitors might also be considered. When compared to CSA, tacrolimus was found more likely to be associated with BKV viremia.[7,18] If viremia persists, reduction of cessation of MMF is advised.[1,17] Another point of importance was that BKV-related diseases were less commonly observed with mammalian target of rapamycin-mTOR inhibitors (sirolimus/everolimus) and the reason was thought to be their relatively weaker immunosuppressant effects or in vitro antiviral properties.[10,22,23] In our cohort, MMF dose reduction or switching to mTORi and discontinuation of tacrolimus or switching to CSA were performed and success was reached.

There is currently no proven antiviral therapy against BKV. There are agents considered potentially effective which were used in patients with reduced immunosuppression, and most data have been obtained from retrospective observational studies.[15] The possible efficacy of cidofovir, a nucleotide analog, has been reported which is thought to inhibit viral replication.[24] Leflunomide, an agent with in vitro anti-BKV properties, was used in cases where MMF was discontinued, but its antiviral efficacy is unclear and side effects include elevated hepatic enzymes, thrombotic microangiopathy, and bone marrow suppression.[25] However, some studies indicated leflunomide and cidofovir might be nephrotoxic and quinolones ineffective.[10] It has been shown that quinolones prevent BKV replication in vitro.[26] Since IvIg contains antibodies against BKV, it can be used as an adjunct therapy in BKVAN as well, its BK-neutralizing effects were seen in some adult studies but for children data are limited.[10,27] Furthermore, its immunomodulatory effects can be useful in preventing rejection during decreased immunosuppression.[10] In our cohort, besides reduced immunosuppression ciprofloxacin was used in 92%, IvIg in 83%, cidofovir in 75%, and leflunomide in 58% of the patients without any serious side effects.

BK resolution has been reported around 70%-83% in pediatric studies.[10] Generally, the desired BKV levels are reached 4-10 weeks after modifications in immunosuppression. In our cohort at a median of 9 months after first detection, serum BKV titers were within the desired limits. There was no significant difference in baseline and follow-up eGFR and proteinuria levels (P = .146 and .433, respectively), and at the last visit, there was only 1 patient who had an eGFR of 17 mL/min/1.73 m^2.

Different studies reported varying rates of rejections which indicates the difficulty of titrating immunosuppression while handling BKV.[21] In a study from Türkiye on 142 pediatric kidney transplant recipients, BK viremia was found in 59% and BKVAN in 8 patients with persistent and high viremia, and despite the change in treatment, 2 of these patients lost their grafts.[28] Patel et al reported graft loss rate due to BKVAN as 0.47%.[21] A recent Turkish study on pediatric kidney recipients showed a rate of 1.4% for BKVAN-related graft loss.[29] Our rejection rate was 83% (10/12) and only 1 patient lost her graft (patient number 4) whose primary diagnosis was reflux nephropathy, received the graft from her father with a 3/6 mismatch, and experienced recurrent urinary tract infections post-transplant. BK viremia was diagnosed at the third month with impaired kidney functions, BKVAN was diagnosed at the fourth month. After BK directed therapy modifications and breakthrough infections, she had 2 rejection episodes and despite treatment progressed to graft failure.

Limitations of our study were its retrospective design, relatively small sample size, and some missing donor details, including the duration of ureteral stent use.

In conclusion, BKV has an increasing impact on kidney transplant recipients and may cause graft loss. Although definite treatment protocols are lacking, with the help of routine monitoring and prompt intervention, firstly with immunoreduction, preservation of graft function is possible. Considering the limited data on BKV in pediatric kidney transplantation, large-scaled prospective studies are needed to identify risk factors and make treatment strategies.

Ethics Committee Approval: Ethics committee approval was received for this study from the institutional ethics committee of Hacettepe University (Approval no: GO22/620, Date: 21.06.2022)

Informed Consent: Verbal informed consent was obtained from the patients who agreed to take part in the study.

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