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Disseminated Adenovirus Nephritis After Kidney Transplantation

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INTRODUCTION

Human adenovirus (HAdV) is a linear, non-enveloped, double-stranded DNA virus that typically causes a mild respiratory, gastrointestinal, and conjunctival illnesses in healthy persons. However, HAdV may cause more severe infection in immunocompromised patients, especially those who have received organ transplants. In kidney transplant recipients, urinary tract infection is the most frequently reported manifestation at 4.8%, with rare dissemination. In a surveillance study, 6.5% of kidney transplant recipients will have a positive polymerase chain reaction (PCR) viremia within the first year, without significant symptoms, that is self-limited. Disseminated HAdV, defined as symptomatic disease of multiple organ systems and associated viremia, is infrequently reported and is associated with transplant rejection, failure, and mortality. A case of disseminated HAdV in a kidney transplant recipient is reported, including a review of management and outcomes in disseminated disease with the goal to guide clinical decision making.

CASE REPORT

A 45-year-old man with a history of end-stage kidney disease, secondary to chronic reflux nephropathy, received a deceased donor kidney transplant. Induction immunosuppression comprised anti-thymocyte globulin and methylprednisolone. Maintenance therapy included tacrolimus, mycophenolate mofetil, and prednisone. His clinical course was complicated by delayed allograft function that required ongoing hemodialysis for 4 weeks.

At his 6-week posttransplantation follow-up visit, he reported a 2-day history of fever, fatigue, cough, and hematuria. He was admitted to the hospital with tachycardia, hypoxemia, and hypotension. He had lymphopenia, thrombocytopenia, and a serum creatinine level of 1.73 mg/dl, compared to his baseline of 1.58 mg/dl. Urinalysis had sterile pyuria and hematuria. Computed tomography of his chest showed an opacity consistent with pneumonia. Vancomycin, piperacillin-tazobactam, and levofloxacin were empirically administered.

Over the next 3 days, he had nightly fevers. His serum creatinine level increased to 2.4 mg/dl. Blood cultures were negative. Studies for serum fungal-(1,3)-B-D-glucan and Aspergillus galactomannan EIA, as well as serum viral PCR cytomegalovirus and human herpesvirus 6 infections, were negative. Urine BK viral particles were not detected by PCR. A nasal swab was positive for HAdV (PCR). Kidney ultrasound demonstrated a 12.6-cm allograft without evidence of renal artery stenosis and with high resistive indices of the upper pole. The 24-hour urine protein was 0.5 g/d at admission and increased to 3.3 g/d by hospital day 7.

A biopsy was performed on the kidney allograft. Paraffin sections showed an edematous parenchyma with a histiocyte-predominant nodular inflammatory infiltrate resembling granulomatous tubulointerstitial nephritis. In place of the epithelioid histiocytes characteristic of granulomas, the predominant cell type in the infiltrate was an atypical monocyte with an eccentrically located, elongated, curved, and crinkled nucleus. These cells infiltrated and distended the tubules, many of which contained epithelial cells with
nuclear viral inclusions as well as apoptic cells (Figure 1). Inflammation with rupture of the tubule appeared to give rise to nodules that, in areas, coalesced into solid inflammatory infiltrate. Remnants of the ruptured tubular basement membranes could be found within the pseudogranulomas on periodic acid–Schiff staining. Strong nuclear staining for adenovirus antigen by cytopathic tubular epithelial cells confirmed adenovirus infection (Arkana Laboratories, Little Rock, AR). No histologic features of acute T-cell or antibody-mediated rejection were found, and the immunofluorescence stain for complement factor C4d was negative. Testing for serum and urine HAdV by PCR returned at 102,801 copies/ml and > 2,000,000 copies/ml, respectively.

Initial treatment consisted of reduction of the patient’s immunosuppression by discontinuing mycophenolate mofetil and targeting a serum tacrolimus trough level of 3 to 7 ng/ml. The prednisone dose was increased from 5 mg to 10 mg daily. Because of the ongoing severity of his allograft dysfunction and associated respiratory illness, he was given i.v. Ig dosed at 0.5 g/kg for 2 days. Symptomatic improvement was reported by the second day after completion of i.v. Ig. Serum creatinine and urine PCR HAdV DNA levels declined steadily, with return to baseline and resolution, respectively (Figure 2). The transplant team was subsequently notified that the recipient of the donor’s other kidney also developed disseminated HAdV.

DISCUSSION

Kidney transplant recipients are at high risk over the first 6 months after transplantation for infectious complications, with bacterial cystitis as 1 of the most common culprits. HAdV is well recognized in the healthy population to be associated with self-limited respiratory, gastroenteritis, and conjunctivitis illness. However, in kidney transplant recipients, the spectrum of HAdV activity ranges from asymptomatic viremia to hemorrhagic cystitis to allograft loss and mortality. In the largest case series to date following 349 kidney transplant recipients over a 3-year period, the incidence of HAdV urinary infection and disseminated disease was 4.8% and 3.1%, respectively. Onset of disease was within the first 3 months in 75% of the patients, and 97% were reported within 1 year. A 10-year review of 170 kidney transplant recipients reported an incidence of 4.7% for hemorrhagic cystitis with median time to onset of 1 year. In comparison, recipients post–allogenic stem cell transplantation have a median time of diagnosis of adenovirus hemorrhagic cystitis and dissemination within the first few weeks and month, respectively. Asymptomatic HAdV viremia was reported as 6.5% from a surveillance study, over a 1-year period, of 92 kidney transplant recipients.

HAdV in kidney transplant recipients may be secondary to reactivation of latent disease, but infection also has been reported to be de novo from environmental sources or from endogenous transmission through a donor organ. The most frequent signs and symptoms at presentation include dysuria, fever, hematuria, sterile (bacterial) pyuria and acute kidney injury. Given the lack of specificity, a broad differential for the etiology of nephritis must be maintained. Common extrakidney manifestations...
among kidney transplant recipients with disseminated disease include orchitis, lymphopenia, gastroenteritis, and pneumonitis.\textsuperscript{1,6–18} Confirmatory diagnostic testing is predominantly through HAdV PCR quantification and tissue biopsy histopathological assessments. Viral culture may be conducted in some cases.\textsuperscript{12} PCR is sensitive to all known serotypes of HAdV, and has the benefit of serial monitoring for response to treatment. PCR testing for HAdV prognostication has been reported in groups receiving hematopoietic stem cell therapy and solid organ transplants.\textsuperscript{9,19,20}

In the present case, this patient had a classically defined presentation of disseminated HAdV. His kidney biopsy findings of inclusion-bearing proximal tubular cells and adjacent noncaseating granulomas in the tubulointerstitium were consistent with HAdV infection and confirmed by immunohistochemical staining.\textsuperscript{21} Given the severity of his acute kidney injury and progressive pneumonia, he was treated with i.v. Ig based on reports for hematopoietic stem cell transplant recipients.\textsuperscript{19,22–24} Cidofovir was not used because of concerns about additional nephrotoxicity in the setting of severe acute kidney injury in the transplanted kidney.

Clinically symptomatic patients with HAdV viremia and 2 or more organ systems involved is considered disseminated disease. Little has been published about clinical management, and current recommendations for treatment are lacking.\textsuperscript{10,25} Overall, 29 cases of disseminated HAdV disease have been reported, including the present case (Table 1). Adverse outcomes have been reported in 6 cases (20%), including 4 deaths and 2

### Table 1. Reported cases of disseminated adenovirus in patients post kidney transplantation

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Author (reference)</th>
<th>Year</th>
<th>Transplant organ</th>
<th>Age (yr)/sex, onset post transplantation</th>
<th>Organ or disease condition</th>
<th>Diagnostic testing</th>
<th>Additional antiviral</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Myerowitz (34)</td>
<td>1975</td>
<td>Kidney</td>
<td>61/F, 40 days</td>
<td>Nephritis, pneumonitis, leukopenia</td>
<td>Unavailable, histological confirmation</td>
<td>None</td>
<td>Dead</td>
</tr>
<tr>
<td>2</td>
<td>Ardehali (35)</td>
<td>2001</td>
<td>Kidney</td>
<td>45/M, 6 yr</td>
<td>Nephritis, pneumonitis, gasitis, cardiac arrest</td>
<td>No PCR done, histological confirmation</td>
<td>None</td>
<td>Dead</td>
</tr>
<tr>
<td>3</td>
<td>Emovon (31)</td>
<td>2003</td>
<td>Kidney-Pancreas</td>
<td>48/F, 540 days</td>
<td>HC, nephritis, septic shock</td>
<td>No PCR, histopathology confirmation</td>
<td>RBV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>4</td>
<td>Rosario (36)</td>
<td>2006</td>
<td>Kidney</td>
<td>58/M, 22 days</td>
<td>Multifluid failure, collitis</td>
<td>PCR: + blood, + stool</td>
<td>None</td>
<td>Died prior to dx</td>
</tr>
<tr>
<td>5</td>
<td>Alsaaed (37)</td>
<td>2007</td>
<td>Kidney</td>
<td>19/M, 12 yr</td>
<td>HC, pneumonia</td>
<td>PCR: + urine/semen testing</td>
<td>CDV</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>6</td>
<td>Keswani (38)</td>
<td>2007</td>
<td>Kidney</td>
<td>5/M, 65 days</td>
<td>HC, gastroenteritis</td>
<td>PCR: + urine, + serum</td>
<td>CDV</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>7</td>
<td>Saquib (39)</td>
<td>2009</td>
<td>Kidney</td>
<td>51/F, 6 yr</td>
<td>Pneumonitis, diarnhea, HA, no nephritis/HC</td>
<td>PCR: + urine, serum, stool, BAL</td>
<td>CDV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>8</td>
<td>Barracough (26)</td>
<td>2009</td>
<td>Kidney</td>
<td>62/M, 29 days</td>
<td>PNA, colitis</td>
<td>No PCR, + urine, + stool, + BAL</td>
<td>CDV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>9</td>
<td>Vase (65)</td>
<td>2009</td>
<td>Kidney</td>
<td>68/M, 14 days</td>
<td>HC, nephritis, severe sepsis with respiratory compromise</td>
<td>+ urine, + serum, −CSF</td>
<td>CDV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>10</td>
<td>Gaspert (6)</td>
<td>2010</td>
<td>Kidney</td>
<td>64/M, 60 days</td>
<td>HC, nephritis, pneumonitis</td>
<td>PCR: + urine, + serum, −BAL</td>
<td>None</td>
<td>Alive, graft loss</td>
</tr>
<tr>
<td>11</td>
<td>Kozlowski (5)</td>
<td>2010</td>
<td>Kidney</td>
<td>44/M, 20 days</td>
<td>HC, nephritis, pneumonitis</td>
<td>PCR: + BAL</td>
<td>GCV</td>
<td>Alive, graft loss</td>
</tr>
<tr>
<td>12</td>
<td>Watcharanan (3)</td>
<td>2011</td>
<td>Kidney</td>
<td>unkn</td>
<td>HC, nephritis</td>
<td>PCR: + serum</td>
<td>None</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>13</td>
<td>Watcharanan (3)</td>
<td>2011</td>
<td>Kidney</td>
<td>unkn</td>
<td>HC, orchitis, diarnhea</td>
<td>PCR: + serum</td>
<td>CDV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>14</td>
<td>Watcharanan (3)</td>
<td>2011</td>
<td>Kidney</td>
<td>unkn</td>
<td>HC, pneumonitis, orchitis</td>
<td>PCR: + serum</td>
<td>CDV</td>
<td>Dead</td>
</tr>
<tr>
<td>15</td>
<td>Watcharanan (3)</td>
<td>2011</td>
<td>Kidney</td>
<td>unkn</td>
<td>HC, URI, orchitis</td>
<td>PCR: + serum</td>
<td>CDV</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>16</td>
<td>Watcharanan (3)</td>
<td>2011</td>
<td>Kidney</td>
<td>unkn</td>
<td>HC, orchitis, graft rejection</td>
<td>PCR: + serum</td>
<td>CDV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>17</td>
<td>Watcharanan (3)</td>
<td>2011</td>
<td>Kidney</td>
<td>unkn</td>
<td>HC, nephritis, enteritis</td>
<td>PCR: + serum</td>
<td>None</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>18</td>
<td>Watcharanan (3)</td>
<td>2011</td>
<td>Kidney</td>
<td>unkn</td>
<td>HC, nephritis, enteritis</td>
<td>PCR: + serum</td>
<td>None</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>19</td>
<td>Watcharanan (3)</td>
<td>2011</td>
<td>Kidney</td>
<td>unkn</td>
<td>HC, leukopenia, enteritis</td>
<td>PCR: + serum</td>
<td>None</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>20</td>
<td>Varma (20)</td>
<td>2011</td>
<td>Kidney-Pancreate</td>
<td>57/M, 11 days</td>
<td>Fever, neuopenia/leukopenia, nephritis</td>
<td>PCR: + serum</td>
<td>i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>21</td>
<td>Sujeet (40)</td>
<td>2011</td>
<td>Kidney</td>
<td>65/F, 3 yr</td>
<td>HC, nephritis, enteritis, respiratory symptoms</td>
<td>PCR: + serum</td>
<td>CDV</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>22</td>
<td>Parasuraman (18)</td>
<td>2013</td>
<td>Kidney</td>
<td>44/M, 22 days</td>
<td>HC, nephritis, enteritis, gastrointestinal</td>
<td>PCR: + urine, + serum</td>
<td>CDV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>23</td>
<td>Dzwood (16)</td>
<td>2014</td>
<td>Kidney</td>
<td>70/F, 810 days</td>
<td>HC, nephritis, gastroenteritis</td>
<td>PCR: + urine, + serum, + stool</td>
<td>CDV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>24</td>
<td>Lachiewicz (17)</td>
<td>2014</td>
<td>Kidney</td>
<td>60/F, 28 days</td>
<td>HC, nephritis, gastroenteritis</td>
<td>PCR: + urine, + serum, + stool</td>
<td>CDV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>25</td>
<td>Zadeh (17)</td>
<td>2014</td>
<td>Kidney</td>
<td>20/F, 2 yr</td>
<td>Nephritis, URI</td>
<td>PCR: + urine, + serum</td>
<td>CDV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>26</td>
<td>Rady (41)</td>
<td>2014</td>
<td>Kidney</td>
<td>63/M, 42 days</td>
<td>HC, nephritis, gastroenteritis</td>
<td>PCR: + urine, serum not performed</td>
<td>GCV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>27</td>
<td>Park (42)</td>
<td>2015</td>
<td>Kidney</td>
<td>32/F, 180 days</td>
<td>HC, nephritis, pneumonitis</td>
<td>PCR: + urine, + serum</td>
<td>RBV + i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>28</td>
<td>Index case</td>
<td>2016</td>
<td>Kidney</td>
<td>45/M, 42 days</td>
<td>HC, nephritis</td>
<td>PCR: + urine, + serum</td>
<td>i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
<tr>
<td>29</td>
<td>Veer (43)</td>
<td>2017</td>
<td>Kidney</td>
<td>75/F, 365 days</td>
<td>HC, nephritis</td>
<td>PCR: + urine, + serum</td>
<td>i.v. Ig</td>
<td>Alive, graft intact</td>
</tr>
</tbody>
</table>

BAL, bronchoalveolar lavage; CSF, cerebrospinal fluid; CDV, cidofovir; dx, diagnosis; F, female; GCV, ganciclovir; HA, headache; HC, hemorrhagic cystitis; M, male; PCR, polymerase chain reaction; PNA, pneumonia; RBV, ribavirin; unkn, unknown; URI, upper respiratory infection; +, positive; −, negative.
kidney allograft losses. In all, 21 case patients (72%) received additional drug interventions along with reduction of their immunosuppressive regimen. Cidofovir, used in 14 of 20 cases, was the most commonly used antiviral agent, either alone or in combination with i.v. Ig.

The first step in standard-of-care for HAdV in transplant recipients is reduction of the immunosuppressive regimen. This intervention is often effective at resolving cases of hemorrhagic cystitis and nephritis. The usual indication for additional therapies of antiviral or i.v. Ig is progressive disease despite immunosuppression reduction. A PCR quantification of 1 log reduction within 2 to 3 weeks is considered a therapeutic response. Antiviral therapies in kidney transplant recipients include cidofovir, ganciclovir, ribavirin, and brincidofovir and i.v. Ig.

Cidofovir, the most commonly used antiviral agent, with activity against all serotypes of HAdV, is a cytosine purine analogue that leads to chain termination. The primary adverse effect is hematological as well as kidney toxicity. Cidofovir is not considered a preferred therapy in kidney transplant recipients owing to clearance by the kidney and risk of nephrotoxicity. Brincidofovir (formally CMX101) is a new lipid derivative of cidofovir. The lipid formulation allows increased intracellular penetration that minimizes proximal tubular accumulation, and as such, may reduce the risk of nephrotoxicity.

The AdVise Study (NCT02087306), a currently completed phase III trial, is predominantly a study of hematopoietic stem cell recipients with small subset of solid organ transplant recipients, evaluating brincidofovir for HAdV disease. Results are expected to be reported soon.

Ganciclovir, a 1-phosphorylated purine analog, has limited effectiveness in HAdV, but there are case reports of its use. Ribavirin, a nucleoside analogue of guanosine, is also not generally recommended due to in vitro activity against only subgroup C of HAdV. However, in the posttransplantation population, subgroup C is a common cause of disease. Intravenous Ig is proposed to promote antiviral activity or to provide passive immunotherapy.

In conclusion, in kidney transplant recipients, HAdV is an uncommonly recognized, but potentially serious, infectious complication. This case reaffirms the clinical context in which to consider such a viral source of infection in kidney transplant recipients. We report the successful management of disseminated HAdV with i.v. Ig as a single agent along with reduction of immunosuppressive therapy. Ongoing prospective studies of HAdV surveillance and antiviral strategies are needed to improve outcomes in this high-risk group.

**DISCLOSURE**
All the authors declared no competing interests.

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**REFERENCES**


