

# Current Knowledge of Vaccinations in Chronic Kidney Disease Patients

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**Abstract:** Chronic kidney disease (CKD) patients are at high risk for infectious complications. This is partly due to their dysfunctional immune system, especially in advanced CKD stages. Vaccination represents an important prevention strategy in these patients, as several studies have reported lower infection rates and significantly reduced morbidity and mortality in hospitals adopting vaccination protocols. However, vaccination rates are particularly low in these patients, and the diminished immune responsiveness remains the main issue of vaccination in CKD patients. Besides, there are various immunization protocols across the world in the absence of optimal vaccination policies. This paper aims to discuss the current knowledge of vaccination in this immunocompromised group of patients based on recent evidence and recommendations.

**Keywords:** immunizations, vaccines, immune system, chronic kidney disease, dialysis, kidney transplant

## Introduction

Infections are recognized as the most common cause of hospitalization and mortality in end-stage renal disease (ESRD) patients, particularly in hemodialysis (HD) patients, after cardiovascular disease.<sup>1</sup> In fact, the incidence of the common infections (urinary tract infections (UTIs), pneumonia, sepsis) is three times greater among CKD patients who have not yet initiated dialysis than in the general population, whereas, dialysis patients have higher annual mortality rates caused by sepsis compared with the general population.<sup>2</sup> Yet, several publications have reported lesser infection rates and therefore decreased morbidity and mortality in hospitals adopting vaccination regimen in CKD and ESRD patients.<sup>1-3</sup> But, these patients, regardless of their initial nephropathy or comorbidities, are less efficiently immunized than the general population.<sup>4</sup> In fact, the particularly dysfunctional immune system of the late-stage chronic kidney disease (CKD) patients, with impaired innate and adaptative immunity, is partly responsible for an increased susceptibility to infection as well as low response to vaccines.<sup>3,4</sup> On one hand, these data suggest that expanding vaccination strategies would diminish infections-related burden and probably improve patients' well-being and survival. However, vaccination practices in these patients are often hindered by the reduced efficacy of the established protocols, the frequent need of booster doses as well as safety issues in renal transplant recipients.<sup>5,6</sup> Therefore, various guidelines were developed to improve the care and diminish morbidity and mortality in this high-risk group of patients. This paper aims to

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discuss the current knowledge of vaccination in these immunocompromised patients based on recent evidence and recommendations.

## Impaired Immune Response in CKD Patients

The chronic decline of kidney function entails abnormalities in both innate and adaptive immunity. As a result, CKD patients are at high risk for infections and experience reduced vaccine effectiveness. In fact, B lymphocyte and CD4+ T lymphocyte are decreased in this population as well as the T-cell response to antigenic stimuli. Moreover, impaired monocyte functioning results in inadequate antigen presentation to the antigen-presenting cells, generating weakened memory cells and inadequate antibody production after vaccination. These disturbances are mostly noted in CKD stages 4 and 5. Additionally, CKD patients are known to have impaired function of neutrophils, with a lower capacity of phagocytosis and a greater rate of apoptosis although their number remains unchanged.<sup>7-12</sup>

In addition, the underlying mechanisms of the impaired immune system in CKD are multifactorial. Several studies have discussed the potential link between endothelial dysfunction and impaired immune function.<sup>13-15</sup> CKD patients have higher levels of endothelial dysfunction markers compared to controls.<sup>16,17</sup>

Besides, uremic toxins, oxidative stress, endothelial dysfunction, low-grade inflammation as well as mineral and bone disorders are involved and may contribute to the impaired immune system in these patients.<sup>8</sup>

## Vaccination in CKD: General Considerations

One of the difficulties in immunization of CKD patients is the lack of an optimal policy, as there are variations in immunization for CKD between countries, mainly due to epidemiological priorities.<sup>1,2</sup>

In fact, the Centers for Disease Control and Prevention (CDC) guidelines for vaccination in CKD summarized in the Recommendations of the Advisory Committee on Immunization Practices (ACIP) recommend for all adults the diphtheria/tetanus, the annual inactivated influenza vaccine, the measles/mumps/rubella (MMR), and the varicella vaccine if not contraindicated. In CKD and dialysis, it adds the hepatitis B vaccine in adapted dose as well as the pneumococcal vaccine.<sup>18</sup>

Besides, here are some fundamental considerations for vaccination practices:<sup>1-3,18-20</sup>

- Early-stage CKD patients can be safely vaccinated as they have mild immune impairment and ESRD patients should not be excluded from routine vaccination with Live-attenuated vaccines (LAV).

- The immune status of transplant candidates must be assessed, and complete appropriate vaccination must be performed in the pretransplant period at least 4 weeks prior to kidney transplantation.

Noteworthy that LAVs are contraindicated in kidney transplant recipients.

Moreover, KDIGO recommend the following guidelines in CKD patients:<sup>20</sup>

- Annual influenza vaccination in adults with CKD, unless contraindicated.
- Vaccination with polyvalent pneumococcus vaccine every 5 years unless contraindicated in CKD stages 4 and 5 and patients at high risk of pneumococcal infection (nephrotic syndrome, diabetes, or those undergoing immunosuppression).

Immunization against hepatitis B in adults with a progressive CKD and have GFR <30 mL/min/1.73 m<sup>2</sup>. The response should be evaluated by an appropriate serological testing.

Furthermore, American guidelines of vaccination in adult solid organ transplantation updated by the American Society of Transplantation (AST) and the Infectious Disease Society of America in 2013 recommend that vaccination status should be documented during pretransplant workup and necessary immunizations must be administered as soon as possible afterwards.<sup>3,18-20</sup>

## Recommended Vaccines for Adult CKD Patients

The recommended vaccines for adult CKD patients are summarized in [Table 1](#).

### Hepatitis B

Hemodialysis patients have an elevated risk of Hepatitis B (HBV) transmission (percutaneous or blood/mucosal exposure) via contaminated surfaces and objects. HBV is very contaminant and persists on environmental surfaces for at least 7 days. Besides, patients with chronic HBV infection are at high risk for cirrhosis and liver cancer.<sup>1-21</sup>

**Table I** Recommended Vaccines for Adults with CKD

Vaccine	Dose and Schedule
Hepatitis B-recombinant	CKD Stages 3–4: Recombivax 10 ug: 3 doses (0, 1, and 6 months) Engerix-B 20 ug: 4 doses (0, 1, 2, and 6 months) Heplisav-B: 2 doses (0 and 1 months) CKD Stage 5: Recombivax 40 ug: 3 doses (0, 1, and 6 months) Engerix-B 40 mg: 4 doses (0, 1, 2, and 6 months) Heplisav-B: 2 doses (0 and 1 months) Booster dose when anti-HBs titer <10 mU/mL
Pneumococcal vaccine	CKD patient naïve to Pneumococcal immunization: - Administer PCV13, - Wait at least 8 weeks after PCV 13 dose then administer PPSV23 (dose1) - Wait at least 5 years after the first dose of PPSV23 then administer PPSV23 (dose 2) *CKD patient previously immunized with PPSV23: - Administer PCV13 at least one year after PPSV23 (dose1) - Wait at least 8 weeks after PCV13dose and at least 5 years after PPSV23 (dose1), then administer PPSV23 (dose 2) *CKD patient previously immunized with PCV13: -Administer PPSV23 (dose1) at least 8 weeks after PCV 13 dose - Wait at least 5 years after PPSV23 dose1, then administer PPSV23 (dose2)
Influenza inactivated	One dose annually before onset of influenza season
Hepatitis A inactivated	Two-dose series of single antigen hepatitis A vaccine (Havrix at 0 and 6–12 months or Vaqta at 0 and 6–18 months; minimum interval, 6 months) - Administer based on risk
Tetanus-diphtheria (Td) and tetanus -diphtheria -acellular pertussis (Tdap)	Primary: three doses (0,1, and 6–12 months) including one (Tdap) Booster dose with (Td) every 10 years
MMR	Administer if no evidence of immunity: 2 doses of MMR at least 28 days apart
VAR	Two doses of VAR vaccine 4–8 weeks apart if not previously received. If previously received one dose, administer 1 dose of VAR at least 4 weeks after the first dose
RZV	Two doses of RZV 2–6 months apart to adults > 50 years regardless of past episode of herpes zoster or ZVL

**Abbreviations:** PCV13, 13-valent pneumococcal conjugate vaccine; PPSV23, 23-valent pneumococcal polysaccharide vaccine; anti-HB, antibody to hepatitis B surface antigen; MMR, measles, mumps, and rubella; RZV, recombinant zoster vaccine; VAR, varicella.

Due to their dysfunctional immune system, infected dialysis patients are likely to become chronic carriers.<sup>1–20,22</sup> Therefore, increasing transmission risk in dialysis units.<sup>22</sup> During the last years, the incidence of HBV infection in HD patients has diminished since the introduction of erythropoiesis-stimulating agents (ESA), the improvement in controls of the blood products for the HBV, the introduction of hepatitis B vaccination programs, additional adherence to rigorous universal precautions to control infection, and regular screening for hepatitis B in dialysis units.<sup>1,3,23</sup>

As early vaccination is correlated with better seroconversion rates, HBV vaccination is recommended as early

in the course of their CKD as possible.<sup>24</sup> In fact, Stage 5 CKD patients present lower seroconversion rates and HBV-antibody responses are less effective and less lasting.<sup>23</sup>

However, there is heterogeneity in practices for the prevention of HBV infection across the world. Firstly, the adequacy of the immune response to hepatitis B vaccination measured by the titer of antibody to hepatitis B surface antigen (anti-HBs) after 3 doses of vaccine at 0-, 1-, and 6-month intervals differs between North America (>10 U/L) and Europe (>100 U/L) according to a Cochrane review.<sup>3,25,26</sup>

As first-generation plasma-derived hepatitis B vaccines were generally ineffective, recombinant yeast-derived second-generation vaccines have progressively replaced them, in order to improve seroconversion rates.<sup>3</sup> Currently, commonly used commercial brands are Recombivax and Engerix-B.<sup>1</sup>

Several studies have compared the intradermal (ID) route to the intramuscular (IM) one. A meta-analysis demonstrated that the ID route was more efficient, and revealed a significantly higher percentage of patients achieving seroconversion in the ID group versus the IM group.<sup>15,27,28</sup>

ESRD patients as well as those undergoing HD require higher vaccine doses to increase seroresponsiveness.<sup>26–29</sup> Currently, recommendations for adults on dialysis are either 40 mg of Recombivax administered at 0.1 and 6 months or Engerix-B administered at 0, 1, 2 and 6 months.<sup>1,3,25–30</sup>

HBV-antibody titer should be assessed 1 to 2 months after the final dose.<sup>30,31</sup> If the latter is <10 mIU/mL, repeating the entire dosing series is suggested with an evaluation of the antibody response in 1 to 4 months. For patients on HD, the need for booster doses should be guided by annual testing of the anti-HB levels.<sup>31–34</sup> A European Consensus group on hepatitis B immunity recommends for immunocompromised patients a regular testing for anti-HBs, and a single booster dose when the titer is inferior to 10 mIU/mL.<sup>3,30–34</sup>

## Influenza and Pneumococcal Vaccines

### Influenza Vaccine

Over the years, epidemics of influenza have caused thousands of deaths, and ESRD patients are likely to present complicated forms of influenza due to their disturbed immune system. Nonetheless, vaccinations have clear benefits in this vulnerable group.<sup>35</sup>

In fact, annual vaccination with the seasonal influenza vaccine for all patients with chronic medical conditions including the dialysis patients is highly recommended as vaccinated ESRD patients had significantly lower infection-related hospitalization and mortality rates. Ideally, vaccination should occur throughout the influenza season prior to the outbreak of the influenza activity.<sup>33,35–38</sup>

Quadrivalent influenza vaccine may be coadministered with pneumococcal vaccines. Besides, in patients aged > 65 years, a high-dose trivalent vaccine may be used.<sup>33,36</sup> Optimal Influenza vaccine schedules in ESRD patients

lack because of the nonavailability of large, prospective randomized studies.<sup>33,37,38</sup> Whereas, in practice, seasonal inactivated influenza vaccine is strongly recommended on an annual basis, and the CDC recommends a 0.5 mL dose of inactivated influenza vaccination for all patients with kidney dysfunction and close contacts including, physicians, nurses, and personnel in the hospital.<sup>1,3,37,38,39</sup>

All types of influenza vaccines have a significantly reduced effect 7 months after the vaccination. A booster dose of the vaccine is not recommended as it is ineffective and thus unnecessary according to a number of studies.<sup>40,41</sup>

Noteworthy, that live-attenuated influenza vaccine is contraindicated in high-risk conditions such as kidney transplant recipients and has not been tested in CKD, ESRD, or in organ transplantation.<sup>3,33,36–38</sup>

### Pneumococcal Vaccine

Due to their weak immune protection, CKD patients, especially children with nephrotic syndrome and elderly on dialysis, are remarkably vulnerable to severe pneumococcal infection.<sup>3</sup> In fact, dialysis patients have a high incidence of respiratory infections with mortality rates up to 16-fold higher compared to the general population. Moreover, community-acquired pneumonia in both dialysis patients and kidney transplant recipients is mainly caused by *Streptococcus pneumoniae*.<sup>42</sup>

Currently, there are 2 different anti-pneumococcal vaccines:<sup>3</sup>

The 13-valent pneumococcal conjugate vaccine (PCV-13: Prevnar 13)

The 23-valent (PPV-23: Pneumovax 23)

The use of both pneumococcal vaccines might provide broader protection. Thus, PCV13 in combination with the PPSV23 vaccine has been included in the vaccination recommendations of immunocompromised individuals including CKD patients.<sup>43</sup>

From 2013 to 2014, according to American, Spanish and French guidelines, PCV-13 followed by a PPV-23, 6–12 months later is recommended for all adults  $\geq 65$  years old, and in congenital or acquired immune-deficient adults of  $\geq 19$  years with a booster dose of PPV-23 at least 5 years later. In PPV-23-vaccinated persons, PCV-13 should be administered at least 1 year after the PPV-23 dose. Additionally, coadministration with the inactivated influenza vaccine may have synergistic positive effects.<sup>44–47</sup>

In practice, based on the current knowledge, IM vaccination is recommended in all ESRD patients with the PCV 13 vaccine and the PPSV23 at least 8 weeks later, then

A booster dose of the PPSV23 is administered every 5 years.<sup>3</sup>

## Tetanus-Diphtheria (Td) and Tetanus-Diphtheria-Acellular Pertussis Vaccines (Tdap)

An Iranian study on a group of HD patients found that only 16% and 24% of them were immune to diphtheria and tetanus, respectively, demonstrating therefore the particularly low seroprotection in these patients.<sup>48</sup> Additionally, survey data report under vaccination against tetanus and diphtheria in adults<sup>48,49</sup>, whereas Maintaining seroprotection against these diseases through adherence to the ACIP-recommended vaccination schedule is important for adults of all ages.<sup>49</sup>

Regarding Pertussis, although vaccines induced protection declines over time, vaccination remains the best protection available against this disease.<sup>1</sup>

Therefore, three doses of the vaccine are recommended at (0,1, and 6–12 months) including One dose of Tdap (vaccine against Tetanus, Diphtheria and Pertussis) should be administered to adults who previously did not receive a dose as an adult or child, followed by a dose of tetanus and diphtheria toxoids (Td) booster every 10 years.<sup>1,48-50</sup> In dialysis patients with open wounds, a tetanus toxoid booster should be administered if in doubt regarding the seroresponsiveness.<sup>2</sup>

## Hepatitis A

Vaccination to hepatitis A virus (HAV) is not universally recommended,<sup>51</sup> and infection with HAV usually provides lifelong immunity in most healthy adults while vaccination offers about 99% seroconversion.<sup>52</sup>

CKD and ESRD patients who should be considered for vaccination are those who travel or live in endemic areas, patients with chronic liver disease, hepatitis C or HIV, homosexual men, and intravenous drug users. These patients are particularly at high risk of HAV associated morbidity and mortality.<sup>52-54</sup> Consequently, vaccination with 2 doses IM at 0 and 6–12 months is recommended in these patients.<sup>53</sup>

The Food and Drug Administration has licensed 2 inactivated vaccines, Harvix (GlaxoSmithKline) and Vaqta (Merck) offered in a 2-dose series.<sup>54</sup> Studies on the safety and efficacy of HAV vaccine in patients with CKD are mitigated. The subcutaneous (SC) route is as effective as the IM route.<sup>52-55</sup>

## Herpes Zoster Vaccine

Herpes zoster vaccine has been reported to decrease shingles and post-herpetic neuralgia.<sup>1</sup> In many countries, ZLV, a live-attenuated vaccine, is still the only available vaccine for Herpes zoster, but, recently, a new Recombinant Zoster Vaccine (RZV), an adjuvant Herpes Zoster (HZ) vaccine, was approved for the prevention of HZ.<sup>2</sup>

Two doses of recombinant zoster vaccine 2 to 6 months apart are recommended in adults aged 50 years or older regardless of past episode of herpes zoster or receipt of zoster vaccine live.<sup>56</sup>

Indeed, given its better efficacy, RZV will certainly replace ZLV and therefore reduce the risk of HZ in vulnerable patients, including, those who are immunosuppressed.<sup>57</sup>

## Measles, Mumps, and Rubella Vaccine (MMR) and Varicella Vaccine (VAR)

In fact, MMR and varicella serology should be assessed prior to transplantation and transplant candidates should be immunized. One or 2 doses of MMR and varicella should be done.<sup>58,59</sup> If seroconversion does not occur, the dose can be repeated once, if time permits prior to transplantation.<sup>58</sup> Additionally, two live vaccines, MMR and varicella for instance, can be both given on the same day; otherwise, the second live vaccine should be given > 28 days later.<sup>58</sup>

## Conclusion

Currently, given the lack of large randomized trials, no optimal vaccination policy in CKD patients is available. In addition, there are differences in vaccination practices across the world, depending on the local epidemiological priorities. Besides, various strategies are used to enhance the vaccine-induced seroconversion rate in advanced CKD patients. Additional research is needed to improve rates of seroresponsiveness, as well as the morbidity and mortality due to infections. Yet, adherence to the available immunization recommendations is highly required in this group of immunocompromised patients.

## Disclosure

The author reports no conflicts of interest in this work.

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