

Vaccination practices in End Stage Renal Failure and Renal Transplantation; Review of current guidelines and recommendations

Nalaka Gunawansa, Roshni Rathore, Ajay Sharma, Ahmed Halawa

Nalaka Gunawansa, National Institute of Nephrology Dialysis and Transplantation, Sri Lanka and Faculty of Health and Science, Institute of Learning and Teaching, University of Liverpool, Liverpool 111, United Kingdom

Roshni Rathore, Department of Renal, University Hospitals of Coventry and Warwickshire and Faculty of Health and Science, Institute of Learning and Teaching, University of Liverpool, Liverpool 111, United Kingdom

Ajay Sharma, Ahmed Halawa, Faculty of Health and Science, Institute of Learning and Teaching, University of Liverpool and Royal Liverpool University Hospital, Liverpool 111, United Kingdom

ORCID number: Nalaka Gunawansa (0000-0003-0098-3855); Roshni Rathore (0000-0002-7659-4672); Ajay Sharma (0000-0002-5579-7470); Ahmed Halawa (0000-0002-7305-446X).

Conflict-of-interest statement: No potential conflicts of interest relevant to this article were reported.

Open-Access: This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

Manuscript source: Unsolicited manuscript

Correspondence to: Nalaka Gunawansa, MBBS, MD, MS, MCh, FCSSL, Vascular and Transplant Surgeon, National Institute of Nephrology Dialysis and Transplantation, Sri Lanka and Faculty of Health and Science, Institute of Learning and Teaching, University of Liverpool, Liverpool 111, United Kingdom. vascular@drnalakagunawansa.com
Telephone: +44-94-773737644

Received: November 24, 2017

Peer-review started: November 24, 2017

First decision: January 6, 2018

Revised: February 2, 2018

Accepted: March 13, 2018

Article in press: March 13, 2018

Published online: June 28, 2018

Abstract

Due to the increased burden of infectious complications following solid organ transplantation, vaccination against common pathogens is a hugely important area of discussion and application in clinical practice. Reduction in infectious complications will help to reduce morbidity and mortality post-transplantation. Immunisation history is invaluable in the work-up of potential recipients. Knowledge of the available vaccines and their use in transplant recipients, donors and healthcare providers is vital in the delivery of quality care to transplant recipients. This article will serve as an aide-memoire to transplant physicians and health care professionals involved in managing transplant recipients as it provides an overview of different types of vaccines, timing of vaccination, vaccines contraindicated post solid organ transplantation and travel vaccines.

Key words: Immunization; Travel vaccines; Infection; Immunosuppression; Inactivated vaccines; Vaccination post-transplant

© **The Author(s) 2018.** Published by Baishideng Publishing Group Inc. All rights reserved.

Core tip: Patients in end-stage renal failure and those after renal transplantation have a higher risk of opportunistic infections with catastrophic complications and poor response to standard vaccines. Special individualized consideration is needed to immunize these

patients within the existing vaccination protocols.

Gunawansa N, Rathore R, Sharma A, Halawa A. Vaccination practices in End Stage Renal Failure and Renal Transplantation; Review of current guidelines and recommendations. *World J Transplant* 2018; 8(3): 68-74 Available from: URL: <http://www.wjgnet.com/2220-3230/full/v8/i3/68.htm> DOI: <http://dx.doi.org/10.5500/wjt.v8.i3.68>

INTRODUCTION

End stage renal disease (ESRD) and long-term haemodialysis results in a state of immune compromise with increased risk of systemic infections. Similarly, Renal transplant (RT) recipients on maintenance immunosuppression, also have an increased life-time risk of opportunistic infections. Post-transplant infectious complications are one of the leading causes of morbidity and mortality in these patients. Although immunization against common pathogens can avoid potentially catastrophic complications, questions remain regarding safety, optimal timing and efficacy in these patients.

Transplant recipients are usually excluded from vaccine trials, leading to a scarcity of data regarding their safety and efficacy in these patients^[1,2]. However, several guidelines have emerged based on individual case series and experience with other immunocompromised patients^[3]. Nevertheless, there exists a clinical hiatus between published guidelines and routine clinical practice, due to safety concerns and fears of increased graft rejection after immunization^[4].

IMMUNE STATUS AND IMMUNIZATION

Post-transplant immunosuppression has a cumulative effect on the immune system, including suppression of antigen presentation, T and B-cell proliferation and antibody production. Therefore, the host serological response to vaccination is suppressed and variable compared to the non-transplant individual^[5]. Furthermore, transplant recipients have a state of hypogammaglobulinaemia, contributing to the low sero-conversion rates^[6]. Therefore, patients with ESRD require a detailed and careful immunization history before enlisting for RT.

TYPE OF VACCINATION: LIVE, KILLED OR INACTIVATED

The place of live attenuated vaccines in transplant recipients remains an area of significant concern. Active viral replication following live vaccines has been demonstrated in immunocompromised hosts, leading to systemic infection. Viral replication can persist for several weeks after vaccination and such vaccines

are recommended at least 6 wk prior to the planned transplant^[7].

Killed and inactivated vaccines are safe in the transplant recipient. These can be administered in line with the immunization schedule for general population. Nevertheless, vaccination in general, is best avoided in the initial 6 mo after RT, where the immunosuppression is maximal. An exception is the influenza vaccine, which is safe as early as 4 wk after RT, to coincide with seasonal outbreaks^[8,9].

TIMING OF VACCINATION

The optimum time for primary vaccination is the pre-transplant phase (Tables 1 and 2). Primary immunization should be carried out early after enlisting for RT due to the variable serological response rates^[10]. This allows use of all types of vaccines including live vaccines, achieving adequate antibody titres and managing possible vaccine related reactions without compromising graft outcome. Live vaccination may interfere with the reading of Tuberculin skin test (TST) which is commonly done in most transplant centres for all potential recipients. Therefore, the TST should be performed simultaneously with live vaccination or delayed by at least 28 d^[11]. Similar difficulties with interpretation have also been reported with the newer interferon gamma release assay (IGRA)^[12].

DOSING

Crespo *et al*^[13] observed that following influenza vaccination, seroconversion rates were 33%, 42% and 82% in ESRD, post-RT and healthy controls respectively. A similar trend of poor sero-conversion is noted with other standard vaccinations among patients with ESRD and after RT. Furthermore, antibody titres tend to decline faster in these patients compared to healthy adults, requiring frequent monitoring of titres and booster vaccination in those who remain sero-negative or have suboptimal antibody levels.

VACCINATION OF HEALTH CARE PERSONNEL AND CARE GIVERS

Certain vaccines such as hepatitis-B are mandatory for all health care workers prior to assuming duties. Other vaccines (*e.g.*, Varicella, influenza) are recommended in most centers and have shown to minimize hospital-acquired infection. All killed or inactivated vaccines are safe in health care workers and close contacts of RT patients. However, live vaccines should be avoided as it can lead to viral shedding and active infection in the transplant recipient^[14].

VACCINATION IN LIVING DONORS

In live donor RT, all donors need to be comprehensively

Table 1 Vaccination in end stage renal disease and pre-transplant

Vaccine	Live/inactivated	Comments
Hepatitis B	Inactivated	Higher concentration in 3-4 divided doses Check seroconversion after 6-12 wk Repeat dosing if HBsAb titre < 10 IU/L
Pneumococcal	Inactivated	(1) Adults (≥ 19 yr), previously unvaccinated; PCV-13 followed 8 wk later by PPSV-23 (2) Previously vaccinated; Single dose of PCV-13, one year after the last PPSV-23
HPV	Inactivated	All patients aged 9-26 yr
Influenza	Live (LAV) Inactivated (TIV)	Contra-indicated Recommended annually
MMR	Live	Mandatory for all paediatric patients; 2 doses given 4 wk apart Single dose booster for all sero-negative adult patients
Rubella		For all seronegative female patients of child-bearing age
Varicella	Live attenuated	For all paediatric and adolescent patients, completed 6 wk before transplant
HZV	Live	Recommended for all elderly (> 60 yr) patients Optional for those 50-60 yr with a history of varicella or zoster No evidence of benefit in those < 50 yr
DTP	Inactivated	For all paediatric patients
Td/ Tdap	Inactivated	Td; Formerly (before 2005) recommended to all adult patients as a booster Tdap to all as a one-time dose followed by Td booster every 10 yr
BCG	Live	Routine neonatal vaccination done in Asia, Eastern Europe, Middle East, Africa and South America Elsewhere, recommended children < 5 yr deemed to be at high risk (see text)

HPV: Human papilloma virus; MMR: Mumps and rubella; DTP: Diphtheria, tetanus and pertussis; BCG: Bacille Calmette-Guérin; LAV: Live attenuated vaccine; TIV: Trivalent inactivated vaccine.

checked for their immunization history. Potential donors should be up-to-date in their age appropriate immunization schedule. Live vaccinations should be avoided within 4 wk of a planned organ donation^[7].

COMMON VACCINES IN THE TRANSPLANT PATIENT

Hepatitis B vaccine

Patients on long-term haemodialysis and after RT have a higher risk of hepatitis-B infection. It may manifest as an aggressive primary infection or reactivation of latent infection, requiring mandatory vaccination of all patients with ESRD, ideally before initiating dialysis. In case it had been missed, it is safe to be given while on dialysis or after RT. However, these patients have poor seroconversion rates (67%-86%), and require higher dosing, given as 20 or 40 (instead of the usual 10) micrograms of recombinant hepatitis-B in 3-4 doses at 0, 1, 2 and 6 mo^[9,10,15].

Hepatitis-B surface antibody (HBsAb) titre should be checked 6-12 wk after completing the vaccination schedule and annually thereafter continuing beyond the transplantation. Those who fail to achieve desired titres (10 IU/L) are recommended a second course of vaccination. Those who fail to achieve the desired titres after two courses should be tested for active infection^[3]. Booster dosing is also recommended for those with sub-optimal HBsAg titres at annual monitoring after RT.

Pneumococcal vaccine

Streptococcus pneumoniae infection can lead to severe and life-threatening pneumonia in ESRD and following

RT. Furthermore, the incidence of invasive pneumococcal infection is also significantly higher in patients after RT compared to the general population. Therefore, routine vaccination is recommended in all patients with chronic kidney disease^[15]. There are two common vaccine variants; the polysaccharide 23-valent (PPSV-23) and conjugated 13-valent (PCV-13), effective against different serotypes of the pathogen^[16]. Both are inactivated vaccines and safe in the immunosuppressed host. Adult (≥ 19 years) patients with chronic kidney disease who have not been previously vaccinated should receive a single dose each of PCV-13 followed 8 wk later by PPSV-23^[15]. If previously vaccinated with PPSV-23, they should receive a single dose of PCV-13 after 1 year from the last dose of PPSV-23^[17]. In immunocompromised hosts including those after RT, a second dose of PPSV-23 is recommended 5 years after the initial dose.

Human papilloma virus vaccine

Human papilloma virus (HPV) infection is one of the commonest prevalent infections among female transplant recipients. In the immunosuppressed host, specific strains of human papilloma virus may result in an increased risk of cervical, vulval or anal carcinoma^[18]. The available trivalent and quadrivalent vaccines are both inactivated and safe in the immunocompromised host. It is recommended for all prospective male and female recipients aged 9-26 years, given prior to RT^[4,15].

Influenza vaccine

Influenza infection can have devastating consequences in the immunosuppressed host. Early studies described prolonged viral shedding and risk of allograft rejection

Table 2 Common vaccinations contra-indicated post-transplant

Vaccine	Remarks
Influenza-Live attenuated	Inactivated is recommended annually
MMR	Recommended pre-transplant to all paediatric patients and sero-negative adult patients
Varicella	Recommended pre-transplant to all paediatric and adolescent recipients
HZV	Recommended pre-transplant to all those > 60 yr and those with a history of varicella or zoster infection (50-60 yr)
BCG	Trials under way for inactivated vaccine-currently not in routine clinical use post-RT
Oral polio vaccine	Inactivated injectable vaccine recommended when indicated
Typhoid	Travel vaccine, not routinely recommended Inactivated variant available for emergency travel

MMR: Mumps and rubella; BCG: Bacille Calmette-Guérin.

with influenza infection, leading to reservations regarding vaccination^[19]. However, a direct causal effect of the vaccine on graft rejection has not been substantiated^[20,21].

Two common vaccine variants exist; the live attenuated vaccine (LAV) and the trivalent inactivated vaccine (TIV). LAV and its intra-nasal variant are contraindicated after RT. The newer adjuvant vaccine is also contra-indicated as it has been shown to induce *de novo* anti-HLA donor specific antibodies, although with no proven clinical implications on the allograft^[3].

Safety and efficacy of TIV is well documented and is recommended annually to all patients with ESRD and post-RT. It has been shown to be safe as early as one month after RT in line with seasonal influenza outbreaks. This current trend has led to a significant shift in practice pertaining to influenza vaccination after RT. A survey by Chon *et al*^[22] covering 239 transplant centers across United States found that 95% of centers recommended influenza vaccine to their recipients compared to 84% in 1999.

Measles, mumps and rubella vaccine

Mumps and rubella (MMR) vaccine is a live attenuated vaccine and is contraindicated after RT. It is mandatory in all prospective paediatric recipients, recommended as a two-dose regimen approximately 4 wk apart after enlisting for RT^[23]. In adults, serological testing is recommended and a single dose vaccination is undertaken for those who are seronegative.

Testing of rubella antibodies is recommended for all prospective female recipients of child-bearing age and vaccination performed if seronegative. Although adult rubella infection is self-limiting, immunization provides protection against congenital rubella syndrome in the event of post-RT pregnancy.

Varicella vaccine

Varicella can cause overwhelming disseminated disease in the immunosuppressed host. The varicella vaccine is live-attenuated and is contra-indicated after RT. It is recommended in all prospective paediatric and adolescent transplant recipients, completed at least 6 wk prior to transplantation^[7,23]. If a deceased donor offer is received before completing 6 wk, RT can still

proceed with a prophylactic regimen of acyclovir. In a study by Broyer *et al*^[24], pre-transplant vaccination showed a dramatic reduction in post-RT varicella from 45% to 12%. Furthermore, the rate of late reactivation as zoster following vaccination (7%) was significantly lower than following primary infection (38%). In the event of a post-RT exposure in seronegative patients, prophylaxis is recommended with acyclovir, valacyclovir or intravenous immunoglobulins^[25].

Herpes zoster virus vaccine

Herpes zoster reactivation (shingles) after transplant can lead to disseminated infection or troublesome herpetic neuralgia. Therefore, vaccination is recommended for all prospective elderly recipients (≥ 60 years) at least 1 mo before RT. In those aged 50-60 years, vaccination is optional and can be considered in those who have a history of varicella or zoster infection^[11]. There is no clear evidence for its benefit in recipients younger than 50 years.

Polio vaccine

The live oral polio vaccine is contra-indicated in transplant recipients and their contacts. Hence, paediatric transplant recipients and their household contacts are excluded from routine polio vaccination programs^[3]. Instead, they are given the inactivated injectable vaccine in-line with the normal immunization schedule.

Diphtheria, tetanus and pertussis vaccine

Diphtheria, tetanus and pertussis (DTP) is an inactivated vaccine and is recommended to all prospective paediatric RT recipients. Until 2005, all prospective adult recipients were recommended a booster dose of tetanus-diphtheria (Td) only. However, a resurgence of pertussis related respiratory illness prompted the inclusion of pertussis vaccine to this schedule. The currently available tetanus toxoid-diphtheria-acellular pertussis (Tdap) vaccine is inactivated and safe in ESRD and after RT. Hence the current recommendation for both groups is a one-time dose of Tdap followed by Td boosters every 10 years^[3,23].

Tuberculosis vaccine

The frequency of post-transplant active tuberculosis is

estimated to be 20-74 times higher than the general population, with a mortality rate reaching 30%^[26]. Immunosuppressive medication may interfere with TST and IGRA used in diagnosis. Despite active disease, sputum smears may remain negative while the clinical manifestations are often atypical, leading to significant diagnostic delays. Furthermore, the disease may actively contribute to allograft dysfunction, resulting in the high morbidity and mortality^[27].

The Bacille Calmette-Guérin (BCG) vaccine is a live vaccine and is contra-indicated after RT. Attempts at producing an effective inactivated vaccine have been largely unsuccessful. The only human trials to show efficacy of an inactivated vaccine was the Dar-Dar and DAR-901 trials conducted in Tanzania for patients with human immunodeficiency virus who were previously vaccinated with BCG at birth. The DAR-901 phase III study showed the inactivated vaccine was well tolerated and did not cause post-vaccination tuberculosis^[28].

Countries in Asia, Eastern Europe, Middle East, Africa and South America have universal neonatal BCG vaccination. In contrast, North America, United Kingdom, Australasia and Western Europe do not practice routine BCG vaccination due to low prevalence of TB, recommending it only to those neonates and children considered to be at a higher risk than the general population. This includes children < 5 years who live in an area of high prevalence, who have parents or grandparents born in a country of high prevalence, who live 3 or more months per year in a country with high prevalence or who have a close contact with diagnosed pulmonary TB^[29].

Meningococcal vaccine

Meningococcal vaccine is usually recommended for patients undergoing splenectomy, those with complement deficiency or with HIV infection. In the transplant patients, it is widely recommended for those intending to travel to endemic regions. More recently, the meningococcal vaccine has been recommended for selected transplant candidates who are likely to receive eculizumab as immunosuppression^[15]. Eculizumab is a complement inhibitor and has been linked to an increased incidence of meningococcal infection^[30]. Accordingly, highly sensitized recipients who are likely to be given eculizumab post-transplant are recommended a two-dose regimen given 8 wk apart in the lead up to RT.

TRAVEL VACCINATION

Vaccinations of transplant recipients who intend to travel overseas to areas where certain infections are endemic, need special consideration. Preplanning allows serological testing before the intended travel to ensure protective serological status. In emergency travel circumstances, passive immunization with immunoglobulins can be

considered^[31].

Hepatitis-A vaccine

Transplant recipients have a poor seroconversion rate to hepatitis-A vaccination and show rapid decline in antibody titres^[32]. For those travelling to endemic regions, the vaccine is recommended in two divided doses given six to twelve months apart. In addition to being a travel vaccine, hepatitis A vaccination is also recommended to RT recipients who are male homosexuals, recreational drug users, receive platelet regular concentrates and those who also have concomitant chronic liver disease^[23].

Typhoid vaccine

The oral live attenuated vaccine is contraindicated after RT. If it is to be given, it must be done prior to transplant for those who reside in or travel to endemic areas. If emergency travel is needed, the inactivated injectable vaccine is recommended^[33].

Polio vaccine

The live oral vaccine is contraindicated after transplant. Any transplant recipient travelling to endemic regions should receive a booster dose of the inactivated injectable vaccine^[7].

Meningitis vaccine

The meningococcal vaccine is inactivated and is recommended to all travelers to endemic areas. This becomes especially important for transplant recipients who travel to regions such as Sub-Saharan Africa and Saudi Arabia, where it is a pre-requisite for travel^[34].

Yellow fever vaccine

Yellow fever becomes endemic in peak seasons in Sub-Saharan Africa and certain regions of South America. The vaccine is a live attenuated and is contraindicated after RT. Hence, those who live or intend to travel to these regions need to be vaccinated before the transplant^[35].

Rabies vaccine

Transplant recipients who are at constant risk of animal exposure such as veterinarians, should be considered for pre-transplant pre-exposure prophylaxis^[15]. In all other transplant recipients, rabies vaccination becomes relevant only after possible rabid exposure. Such patients require comprehensive post-exposure prophylaxis. This comprises of injectable intramuscular vaccines in divided doses coupled with human rabies immunoglobulin^[36].

Japanese encephalitis vaccine

Transplant recipients travelling to endemic East Asia and South-East Asia are recommended Japanese encephalitis vaccination. The newer killed inactivated vaccine is safe and recommended in two doses given 4

wk apart prior to intended travel^[37].

CONCLUSION

Patients with ESRD and after RT are a distinct cohort that carry an increased risk of common infections, potentially catastrophic complications of such infections as well as reduced immunogenicity following immunization. In general, all immunization related details should be obtained prior to enlisting for RT. Any planned vaccines should be administered early in the pre-transplant phase at least 4 wk before the RT. While inactivated vaccines are considered safe beyond the first 6 mo after RT, live vaccines are contra-indicated throughout the post-transplant period. The reduced seroconversion rates and faster antibody clearance in these patients mandates regular screening for antibody titres and administration of booster doses when necessary.

REFERENCES

- 1 **Stark K**, Günther M, Schönfeld C, Tullius SG, Bienzle U. Immunisations in solid-organ transplant recipients. *Lancet* 2002; **359**: 957-965 [PMID: 11918932 DOI: 10.1016/S0140-6736(02)08028-5]
- 2 **Kotton CN**. Vaccinations in kidney transplant patients: searching for optimal protection. *Clin J Am Soc Nephrol* 2011; **6**: 2099-2101 [PMID: 21852666 DOI: 10.2215/CJN.07330711]
- 3 **Duchini A**, Goss JA, Karpen S, Pockros PJ. Vaccinations for adult solid-organ transplant recipients: current recommendations and protocols. *Clin Microbiol Rev* 2003; **16**: 357-364 [PMID: 12857772 DOI: 10.1128/CMR.16.3.357-364.2003]
- 4 **Avery RK**, Michaels M. Update on immunizations in solid organ transplant recipients: what clinicians need to know. *Am J Transplant* 2008; **8**: 9-14 [PMID: 18093271 DOI: 10.1111/j.1600-6143.2007.02051.x]
- 5 **Gangappa S**, Kokko KE, Carlson LM, Gourley T, Newell KA, Pearson TC, Ahmed R, Larsen CP. Immune responsiveness and protective immunity after transplantation. *Transpl Int* 2008; **21**: 293-303 [PMID: 18225995 DOI: 10.1111/j.1432-2277.2007.00631.x]
- 6 **Pollock CA**, Mahony JF, Ibels LS, Caterson RJ, Waugh DA, Wells JV, Sheil AG. Immunoglobulin abnormalities in renal transplant recipients. *Transplantation* 1989; **47**: 952-956 [PMID: 2660357 DOI: 10.1097/00007890-198906000-00007]
- 7 **Danziger-Isakov L**, Kumar D; AST Infectious Diseases Community of Practice. Vaccination in solid organ transplantation. *Am J Transplant* 2013; **13** Suppl 4: 311-317 [PMID: 23465023 DOI: 10.1111/ajt.12122]
- 8 **Candon S**, Thervet E, Lebon P, Suberbielle C, Zuber J, Lima C, Charron D, Legendre C, Chatenoud L. Humoral and cellular immune responses after influenza vaccination in kidney transplant recipients. *Am J Transplant* 2009; **9**: 2346-2354 [PMID: 19656126 DOI: 10.1111/j.1600-6143.2009.02787.x]
- 9 **Kidney Disease: Improving Global Outcomes (KDIGO) Transplant Work Group**. KDIGO clinical practice guideline for the care of kidney transplant recipients. *Am J Transplant* 2009; **9** Suppl 3: S1-S155 [PMID: 19845597 DOI: 10.1111/j.1600-6143.2009.02834.x]
- 10 Recommendations for preventing transmission of infections among chronic hemodialysis patients. *MMWR Recomm Rep* 2001; **50**: 1-43 [PMID: 11349873]
- 11 **Kim DK**, Riley LE, Harriman KH, Hunter P, Bridges CB. Advisory Committee on Immunization Practices Recommended Immunization Schedule for Adults Aged 19 Years or Older - United States, 2017. *Am J Transplant* 2017; **17**: 1132-1135 [PMID: 28371534 DOI: 10.1111/ajt.14244]
- 12 **Horne DJ**, Narita M, Spitters CL, Parimi S, Dodson S, Limaye AP. Challenging issues in tuberculosis in solid organ transplantation. *Clin Infect Dis* 2013; **57**: 1473-1482 [PMID: 23899676 DOI: 10.1093/cid/cit488]
- 13 **Crespo M**, Collado S, Mir M, Cao H, Barbosa F, Serra C, Hidalgo C, Faura A, Montero M, García de Lomas J, Horcajada JP, Puig JM, Pascual J. Efficacy of influenza A H1N1/2009 vaccine in hemodialysis and kidney transplant patients. *Clin J Am Soc Nephrol* 2011; **6**: 2208-2214 [PMID: 21852661 DOI: 10.2215/CJN.02160311]
- 14 **Mallory RM**, Yi T, Ambrose CS. Shedding of Ann Arbor strain live attenuated influenza vaccine virus in children 6-59 months of age. *Vaccine* 2011; **29**: 4322-4327 [PMID: 21513761 DOI: 10.1016/j.vaccine.2011.04.022]
- 15 **Kotton CN**. Immunization after kidney transplantation-what is necessary and what is safe? *Nat Rev Nephrol* 2014; **10**: 555-562 [PMID: 25072119 DOI: 10.1038/nrneph.2014.122]
- 16 **Jacobson RM**, Poland GA. The pneumococcal conjugate vaccine. *Minerva Pediatr* 2002; **54**: 295-303 [PMID: 12131865]
- 17 **Centers for Disease Control and Prevention (CDC)**. Trends in tuberculosis--United States, 2012. *MMWR Morb Mortal Wkly Rep* 2013; **62**: 201-205 [PMID: 23515056]
- 18 **Hinten F**, Meeuwis KA, van Rossum MM, de Hullu JA. HPV-related (pre)malignancies of the female anogenital tract in renal transplant recipients. *Crit Rev Oncol Hematol* 2012; **84**: 161-180 [PMID: 22425015 DOI: 10.1016/j.critrevonc.2012.02.008]
- 19 **Keane WR**, Helderma JH, Luby J, Gailiunas P, Hull AR, Kokko JP. Epidemic renal transplant rejection associated with influenza A victoria. *Proc Clin Dial Transplant Forum* 1978; **8**: 232-236 [PMID: 386316]
- 20 **Grekas D**, Alivannis P, Kiriazopoulou V, Dioudis C, Sioulis A, Derveniotis V, Tourkantonis A. Influenza vaccination on renal transplant patients is safe and serologically effective. *Int J Clin Pharmacol Ther Toxicol* 1993; **31**: 553-556 [PMID: 8294168]
- 21 **Scharpé J**, Evenepoel P, Maes B, Bammens B, Claes K, Osterhaus AD, Vanrenterghem Y, Peetermans WE. Influenza vaccination is efficacious and safe in renal transplant recipients. *Am J Transplant* 2008; **8**: 332-337 [PMID: 18162092 DOI: 10.1111/j.1600-6143.2007.02066.x]
- 22 **Chon WJ**, Kadambi PV, Harland RC, Thistlethwaite JR, West BL, Udani S, Poduval R, Josephson MA. Changing attitudes toward influenza vaccination in U.S. Kidney transplant programs over the past decade. *Clin J Am Soc Nephrol* 2010; **5**: 1637-1641 [PMID: 20595695 DOI: 10.2215/CJN.00150110]
- 23 **Kim DK**, Riley LE, Harriman KH, Hunter P, Bridges CB; Advisory Committee on Immunization Practices. Recommended Immunization Schedule for Adults Aged 19 Years or Older, United States, 2017. *Ann Intern Med* 2017; **166**: 209-219 [PMID: 28166560 DOI: 10.7326/M16-2936]
- 24 **Broyer M**, Tete MJ, Guest G, Gagnadoux MF, Rouzioux C. Varicella and zoster in children after kidney transplantation: long-term results of vaccination. *Pediatrics* 1997; **99**: 35-39 [PMID: 8989334 DOI: 10.1542/peds.99.1.35]
- 25 **Zuckerman RA**, Limaye AP. Varicella zoster virus (VZV) and herpes simplex virus (HSV) in solid organ transplant patients. *Am J Transplant* 2013; **13** Suppl 3: 55-66; quiz 66 [PMID: 23347214 DOI: 10.1111/ajt.12003]
- 26 **Muñoz P**, Rodríguez C, Bouza E. Mycobacterium tuberculosis infection in recipients of solid organ transplants. *Clin Infect Dis* 2005; **40**: 581-587 [PMID: 15712081 DOI: 10.1086/427692]
- 27 **Subramanian AK**, Morris MI; AST Infectious Diseases Community of Practice. Mycobacterium tuberculosis infections in solid organ transplantation. *Am J Transplant* 2013; **13** Suppl 4: 68-76 [PMID: 23465000 DOI: 10.1111/ajt.12100]
- 28 **von Reyn CF**, Lahey T, Arbeit RD, Landry B, Kailani L, Adams LV, Haynes BC, Mackenzie T, Wieland-Altner W, Connor RI, Tvaroha S, Hokey DA, Ginsberg AM, Waddell AR. Safety and immunogenicity of an inactivated whole cell tuberculosis vaccine

- booster in adults primed with BCG: A randomized, controlled trial of DAR-901. *PLoS One* 2017; **12**: e0175215 [PMID: 28498853 DOI: 10.1371/journal.pone.0175215]
- 29 **Zwerling A**, Behr MA, Verma A, Brewer TF, Menzies D, Pai M. The BCG World Atlas: a database of global BCG vaccination policies and practices. *PLoS Med* 2011; **8**: e1001012 [PMID: 21445325 DOI: 10.1371/journal.pmed.1001012]
- 30 **Struijk GH**, Bouts AH, Rijkers GT, Kuin EA, ten Berge IJ, Bemelman FJ. Meningococcal sepsis complicating eculizumab treatment despite prior vaccination. *Am J Transplant* 2013; **13**: 819-820 [PMID: 23289494 DOI: 10.1111/ajt.12032]
- 31 **Nakamura A**, Osonoi T, Terauchi Y. Relationship between urinary sodium excretion and pioglitazone-induced edema. *J Diabetes Investig* 2010; **1**: 208-211 [PMID: 24843434 DOI: 10.1111/j.2040-1124.2010.00046.x]
- 32 **Stark K**, Günther M, Neuhaus R, Reinke P, Schröder K, Linnig S, Bienzle U. Immunogenicity and safety of hepatitis A vaccine in liver and renal transplant recipients. *J Infect Dis* 1999; **180**: 2014-2017 [PMID: 10558960 DOI: 10.1086/315125]
- 33 **Anwar E**, Goldberg E, Fraser A, Acosta CJ, Paul M, Leibovici L. Vaccines for preventing typhoid fever. *Cochrane Database Syst Rev* 2014; **2**: CD001261 [PMID: 24385413 DOI: 10.1002/14651858.CD001261.pub3]
- 34 **Kotton CN**, Hibberd PL; AST Infectious Diseases Community of Practice. Travel medicine and transplant tourism in solid organ transplantation. *Am J Transplant* 2013; **13** Suppl 4: 337-347 [PMID: 23465026 DOI: 10.1111/ajt.12125]
- 35 **Kadam PD**, Chuan HH. Erratum to: Rectocutaneous fistula with transmigration of the suture: a rare delayed complication of vault fixation with the sacrospinous ligament. *Int Urogynecol J* 2016; **27**: 505 [PMID: 26811110 DOI: 10.1007/s00192-016-2952-5]
- 36 Reorganized text. *JAMA Otolaryngol Head Neck Surg* 2015; **141**: 428 [PMID: 25996397 DOI: 10.1001/jamaoto.2015.0540]
- 37 **Fischer M**, Lindsey N, Staples JE, Hills S; Centers for Disease Control and Prevention (CDC). Japanese encephalitis vaccines: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 2010; **59**: 1-27 [PMID: 20224546]

P- Reviewer: Chang CC **S- Editor:** Cui LJ **L- Editor:** A
E- Editor: Tan WW





Published by **Baishideng Publishing Group Inc**
7901 Stoneridge Drive, Suite 501, Pleasanton, CA 94588, USA
Telephone: +1-925-223-8242
Fax: +1-925-223-8243
E-mail: bpgoffice@wjgnet.com
Help Desk: <http://www.f6publishing.com/helpdesk>
<http://www.wjgnet.com>

