Transplantation programs facing lack of empirical evidence on SARS-CoV-2 vaccination: A society recommendation consensus update

Nora Nevermann1 | Leke Wiering1 | Helen Wu1 | Philipp Moroder2 | Andreas Brandl3 | Brigitta Globke1 | Felix Krenzien1 | Nathanael Raschzok1 | Wenzel Schöning1 | Georg Lurje1 | Robert Öllinger1 | Moritz Schmelzle1 | Johann Pratschke1 | Paul Viktor Ritsch1,4

1 Department of Surgery, Charité – Universitätsmedizin Berlin Humboldt-Universität zu Berlin, and Berlin Institute of Health, Berlin, Germany
2 Department for Shoulder and Elbow Surgery, Center for Musculoskeletal Surgery, Charité – Universitätsmedizin Berlin Humboldt-Universität zu Berlin, and Berlin Institute of Health, Berlin, Germany
3 Digestive Unit, Champalimaud Foundation, Lisbon, Portugal
4 Clinician Scientist Program, Berlin Institute of Health (BIH), Berlin, Germany

Correspondence
Paul Ritschl, Charité - Universitätsmedizin Berlin, Chirurgische Klinik, Campus Charité Mitte, Campus Virchow-Klinikum, Augustenburger Platz 1, D-13353 Berlin, Germany.
Email: paul.ritschl@charite.de

Abstract

Background: Since phase III trials for the most prominent vaccines excluded immunocompromised or immunosuppressed patients, data on safety and efficacy of SARS-CoV-2 vaccines for recipients of solid organ transplantations are scarce.

Aims: Our study offers a synthesis of expert opinions aligned with available data addressing key questions of the clinical management of SARS-CoV-2 vaccinations for transplant patients.

Method: An online research was performed retrieving available recommendations by national and international transplantation organizations and state institutions on SARS-CoV2 vaccination management for transplant recipients.

Results: Eleven key statements were identified from recommendations by 18 national and international societies, and consensus for the individual statements was evaluated by means of the Society Recommendation Consensus score. The highest consensus level (SRC A) was found for prioritized access to vaccination for transplant patients despite anticipation of a weakened immune response. All currently authorized vaccines can be considered safe for transplant patients (SRC A). The handling of immunosuppressive medication, the timely management of vaccines, and other aspects were aligned with available expert opinions.

Conclusion: Expert consensus can be determined for crucial aspects of the implementation of SARS-CoV-2 vaccination programs. We hereby offer a tool for immediate decision-making until empirical data becomes available.
1 | INTRODUCTION

Since the first emergency use authorizations of SARS-CoV-2 vaccines, large vaccination campaigns have been launched worldwide. However, transplantation programs are faced with a dramatic lack of data to guide the implementation of such campaigns with regard to transplant recipients and patients awaiting transplantation. The phase III trials for the most prominent vaccines - BNT162b2 mRNA vaccine (Pfizer/BioNTech), mRNA-1273 vaccine (Moderna), ChAdOx1-nCoV-19 chimpanzee adenovirus (ChAd) vector vaccine (AstraZeneca/University of Oxford) - demonstrated a high level of efficacy in preventing coronavirus disease (COVID-19) as well as a corresponding high safety profile. All three trials explicitly excluded immunocompromised or immunosuppressed patients.1–3 Faced with the inevitable lack of empiric guidelines, our study offers a synthesis of expert opinions extracted from recommendations and statements made by national and international transplantation societies in the context of available data. It is our aim to provide a tool for the clinical management of SARS-CoV-2 vaccinations within solid organ transplantation (SOT) programs.

2 | METHODS

An online research was performed retrieving available publications by national and international transplantation organizations and state institutions concerning recommendations on SARS-CoV-2 vaccination management for transplant recipients and patients on transplant waiting lists. Transplantation societies or institutions were included for which published statements or recommendations concerning transplant patients or waitlisted patients and SARS-CoV-2 vaccinations were available via online research. The retrieval of relevant statements and recommendations was performed by two independent researchers. Medically trained translators were consulted when necessary. Statements were included if recommended by more than two independent societies. The wording was validated by agreement of all researchers. Consensus for the individual statements was evaluated by means of the Society Recommendation Consensus (SRC) score.4 Accordingly, all consenting recommendations were represented by one point and added up. Dissenting recommendations were subtracted (value of -1) from the number of societies supporting the recommendation. Partial consent or a recommendation for a case-by-case decision was marked as "partial agreement" and represented by 0 points. Missing comments of individual societies on a specific topic were marked as "not available (n.a.)" and represented by 0 points. A "strong" recommendation was defined as consensus within >50% of society recommendations (SRC A) and "medium" and "low" recommendation as consensus of >25% and <25% of retrieved recommendations (SRC B and C). No ethical approval was necessary as all information is accessible online.

3 | RESULTS

Recommendations or statements by 18 national and international societies were retrieved (Table 1 for according sources and links). Eleven key statements were defined and are listed in Table 2. The statements were then categorized according to the SCR-category A (strong consensus), B (medium consensus), and C (low consensus). Details of the SRC score calculation are provided in Figure 1. Individual statements are discussed hereafter.

3.1 | Recommendations with strong consensus (SCR A)

3.1.1 | Donors with prior SARS-CoV-2 infection can be considered for donation after clearance of infection

A strong consensus was found that prior SARS-CoV-2 infection does not constitute a contraindication for organ donation. The American Society of Transplantation (AST) requires a timely delay of 21 days between initial COVID-19 symptoms in addition to repeated negative PCR testing.5 Additionally, the German Organ Transplantation Foundation (DSO) requires the absence of clinical symptoms and no radiologic signs of pulmonary manifestation of COVID-19.6 The Canadian Society of Transplantation (CST) suggests a 4-week period after the first positive PCR test.7 The British National Health Service demands a case-by-case decision after moderate and severe COVID-19 (defined as need for hospitalization) assuming chronic end-organ damage.8 In contrast, the Chinese government issued a statement that prior SARS-CoV-2 infection is to be considered a contraindication and negative antibody results (IgG and IgM) are required before organ retrieval.9 With regard to the vaccination of potential organ donors The Transplant Society states that the vaccination of the donor does not - under any circumstance - represent a contraindication for organ retrieval.10

3.1.2 | Prioritized access to COVID-19 vaccinations is recommended for patients who received an organ transplant or are awaiting transplantation

Unanimous consensus was found for prioritized access to SARS-CoV-2 vaccinations. A high hospitalization and mortality rate were shown for SOT recipients (OR 2.7 and 4.2). A particularly high risk of severe COVID-19 and mortality was shown for kidney transplant (HR 4.6 and
| Institution/Society                                      | Link to recommendation                                                                 | Last update | Date of access |
|----------------------------------------------------------|----------------------------------------------------------------------------------------|-------------|----------------|
| Transplant Society of Australia and New Zealand (TSANZ)  | https://tsanz.com.au/information/covid-19.htm                                         | 14.04.2021  | 27.04.2021     |
| Belgian Transplantation Society / Superior Health Council, Belgium   | https://www.health.belgium.be/fr/avis-9618-la-priorisation-des-groupes-risque-pour-la-vaccination-contre-le-sars-cov-2-phase-ib | 05.02.2021  | 06.04.2021     |
| Brazilian Organ Transplantation Society                  | https://site.abto.org.br/blog/informacoes/transplante-para-orgaos-soludos-e-vacina-para-covid-19/ | 22.02.2021  | 10.04.2021     |
| Canadian Society of Transplantation / Canadian Blood service | https://profedu.blood.ca/sites/msi/files/20210224_covid-19_consensus_guidance.pdf | 18.05.2021  | 22.05.2021     |
| Minister for Health, People's Republic of China          | http://www.organtranspl.com/cn/article/doi/10.3969/j.issn.1674-7445.2020.06.001        | 12.04.2021  | 16.04.2021     |
| Biomedical Agency, France                                | https://www.agence-biomedecine.fr/IMG/pdf/mise_a_jour_recommandations_abm_020321-2.pdf | 19.04.2021  | 06.05.2021     |
| German Organ Transplantation Foundation                  | https://www.d-t-g-online.de/index.php/covid-19; https://www.infektionsschutz.de/coronavirus/schutzimpfung | 26.04.2021  | 27.04.2021     |
| National Health Service, Great Britain                   | https://nhsbtdb.be.blob.core.windows.net/umbraco-assets-corp/21654/dat3911.pdf         | 09.04.2021  | 16.05.2021     |
| Ministry of Health, Italy / Italian Society of Organ Transplant | http://www.trapianti.salute.gov.it/trapianti/dettaglioComunicatiNotizieCnt.jsp            | 30.03.2021  | 10.04.2021     |
| Japanese Transplantation Society                         | https://www.kansensho.or.jp/uploads/files/guidelines/2102_covid_vaccine_2.pdf          | 26.02.2021  | 05.04.2021     |
| Dutch Transplant Foundation                              | https://lci.rivm.nl/handleiding-covid-19-vaccinatie-van-immuungecompromitteerde-patienten | 26.03.2021  | 10.04.2021     |
| Portuguese Institute for Blood and Transplantation       | http://ipst.pt/files/TRANSPLANTACAO/CircularNormativaConjunta_2_IPST_DGS_1atualizacao_2.pdf | 24.03.2021  | 10.04.2021     |
| Scandiatransplant                                         | http://www.scandiatransplant.org/members/prevention-of-transmission-of-infectious-diseases/InfectionGroup_Guidelines_with9.March2021_addendum.pdf | 09.03.2021  | 18.04.2021     |
| Swisstransplant                                          | https://www.swisstransplant.org/fileadmin/user_upload/Infos_und_Material/Fachpersonen/Corona/COVID-19_vaccination.pdf | 31.01.2021  | 18.04.2021     |
| Federation of Scientific Medical Societies, Spain        | https://www.asociacionasacco.es/wp-content/uploads/2021/02/20210128-FACME-trasplante-organos-solidos-2801.pdf | 28.01.2021  | 10.04.2021     |
| American Society of Transplantation                      | https://www.myast.org/sites/default/files/2021%2003%2018%20COVID19%20VACCINE%20FAQ%20update.pdf | 07.05.2021  | 18.05.2021     |
| The Transplantation Society                              | https://tts.org/index.php?option=com_content&view=article&id=749&Itemid=140             | 01.03.2021  | 16.04.2021     |
| The International Society of Heart and Lung Transplantation | https://ishlt.org/ishlt/media/documents/SARS-CoV-2_Guidance-for-Cardiothoracic-Transplant-and-VAD-center.pdf | 01.02.2021  | 16.04.2021     |
TABLE 2  Individual statements with calculated Society Recommendation Consensus (SRC)

| Statement                                                                 | Recommendation with strong consensus (SRC A) | Consensus US* |
|---------------------------------------------------------------------------|-----------------------------------------------|---------------|
| 1  Donors with prior SARS-CoV-2 infection can be considered for donation after clearance of infection. | 13/18 |
| 2  Prioritized access to SARS-CoV-2 vaccinations is recommended for patients who received an organ transplant or are awaiting transplantation. | 13/18 |
| 3  All currently authorized vaccines can be considered safe for SOT recipients. | 11/18 |
| 4  Immunosuppressed patients may exhibit a weakened response to SARS-CoV-2 vaccines. | 11/18 |
| 5  Transplantation should not be postponed due to vaccination schedules. | 10/18 |

**Recommendation with medium consensus (SRC B)**

| Statement                                                                 | Recommendation with medium consensus (SRC B) | Consensus US* |
|---------------------------------------------------------------------------|-----------------------------------------------|---------------|
| 6  Vaccination respecting a timely delay of 2 weeks prior to transplantation and 4 weeks after transplantation should be favored. | 9/18 |
| 7  SARS-CoV-2 antibody testing is not recommended for clinical decision-making | 8/18 |
| 8  In case of T-/ or B-cell depleting immunosuppression, a delay of 3 months until vaccination can be recommended. | 8/18 |
| 9  A delay of 2 weeks between SARS-CoV-2 vaccination and other vaccinations can be recommended. | 5/18 |

**Recommendation with low consensus (SRC C)**

| Statement                                                                 | Recommendation with low consensus (SRC C) | Consensus US* |
|---------------------------------------------------------------------------|-------------------------------------------|---------------|
| 10 Immunosuppression should not be suspended or reduced during the process of vaccination. | 4/18 |
| 11 After treatment of an acute rejection, a delay until vaccination can be recommended. | 3/18 |

*Number of societies which support the statement (dissenting expert opinions were subtracted from the number of supporting opinions).

---

**FIGURE 1**  Positions of individual societies were defined as “consenting” (mark-up: green, attributed value: +1), “dissenting” (mark-up: red, attributed value: –1), “case-by-case decision/partial agreement” (mark-up: orange, attributed value: 0), or “not discussed” (mark-up: white, attributed value: 0). SRC categories were defined as strong = A (>50% of the societies support the statement); medium = B (25%-50% of the societies support the statement), low recommendation = C (<25% of the societies support the statement)

Abbreviation: SCR, Society Recommendation Consensus.

---

7.1; 30-day mortality rate: 23%) and lung transplant recipients (HR 3.5 and 6.2).11 For liver transplant recipients, a comparable COVID-19-related mortality but a higher rate of intensive care admission was found compared to the general population. Enhanced social distancing is discussed as a protective mechanism.12 Furthermore, chronically ill patients awaiting SOT are at higher risk for severe courses of COVID. For a cohort of 197 SARS-CoV-2 infected waitlisted patients, a mortality of 10.2% was shown.12 Classification of SOT recipients and waitlisted patients within the high-risk group is thus justified. Vaccination of household members with the aim to counterbalance an estimated lower efficacy of the vaccine is discussed, but no recommendation consensus can be deduced.5,14–16
3.1.3 | All currently authorized vaccines can be considered safe for transplant patients and patients awaiting transplantations

Merely 0.6% of the 100,000 participants included in the vaccines’ clinical trials of Pfizer and Moderna presented preexisting liver or kidney disease (excluded in the AstraZeneca trial). Immunocompromised or immunosuppressed patients were excluded by all three vaccine trials. A first cohort study including 187 SOT recipients describes mild vaccine-related reactions as expected and no episode of acute rejection, COVID-19 outbreak, or other severe secondary reactions.

Faced with insufficient evidence, a strong expert opinion consensus can be found to classify all currently authorized vaccines (mRNA and adenovirus vector based) as safe for use in immunosuppressed patients. Vaccines based on inactivated coronaviruses (e.g., CoVaxin, Bharat Biotech; BBIBP-CorV, Sinopharm) are proposed to be contraindicated for immunosuppressed patients, but currently no vaccine of this group gained emergency use authorization.

As discussed by the Japanese Transplantation Society, merely 5% of the phase III trial population is of Asian ethnicity leaving an uncertain risk of a non-representative cohort even for the general population.

3.1.4 | Immunosuppressed patients may exhibit a weakened response to SARS-CoV-2 vaccines (SRC A)

For a first cohort of 436 vaccinated transplant recipients, a detectable antibody titer at 20 days after the first injection was detected in 17% of participants. A recent study that compared the antibody response of 34 SOT (kidney and heart transplantations) and 116 health care workers found a significantly lower response rate of 58.8% versus 100% (median titers: 1370 vs. 11710, p < 0.001). Anti–metabolite immunosuppression (AMI) therapy (33% in those receiving AMI vs. 79%) and high dose corticosteroids in the last 12 months were found to be associated with low antibody response. A second study (136 kidney recipients and 25 health controls) confirms a lower response rate (37% vs. 100% with a lower anti-spike level). Several transplant societies (e.g., NTS, Netherlands) favor the use of RNA-based vaccines as a higher efficacy for elderly people - with presumed lower immunogenicity - was shown and to avoid the theoretical risk of replication of the vector virus - per se replication deficient - in a (strongly) immunosuppressed patient. Attenuated immune response for cirrhotic patients is well described, but the high risk of severe COVID-19 may nevertheless justify prioritized vaccination of immunosuppressed patients and patients awaiting transplantation.

3.1.5 | Transplantation should not be postponed due to vaccination schedules (SRC A)

Furthermore, a strong consensus was found with regard to prioritizing transplantation over vaccination. The absence of a vaccination should not contraindicate or delay a transplantation. Excluding patients from transplantation after vaccination with a live attenuated vaccine is discussed in Germany. Up-to-date, no SARS-CoV-2 vaccine of this category gained authorization.

The Pan-London Transplant Collaborative Ethics Group discusses handling of individuals that refuse SARS-CoV-2 vaccination - potentially up to 40% of the population - stating that, in case of additional risk factors for severe COVID-19 infections and as long as transmission rates are high, it may not be appropriate to perform transplantation in the absence of vaccination.

3.2 | Recommendations with medium consensus (SCR B)

3.2.1 | Vaccination respecting a timely delay of 2 weeks prior to transplantation and 4 weeks after transplantation should be favored

Consensus was found for respecting a delay of 2 weeks prior to transplantation (if transplantation date is foreseeable) and 4 weeks post-transplantation, in analog to recommendations for other vaccines.

A longer time stretch since (kidney) transplantation was shown to correlate with seroconversion after SARS-CoV-2 vaccination compared to the non-seroconverted group. Anti–metabolite maintenance immunosuppression was associated with a low seroconversion rate. Clear evidence on the effects of specific immunosuppression regimens of vaccine response is pending.

Reduced vaccine immunogenicity after liver transplantations is well evaluated for hepatitis A and B virus, and pneumococcal and influenza vaccines. Likewise, prioritized vaccination of patients on transplant waiting lists should be considered.

3.2.2 | SARS-CoV-2 antibody testing is not recommended for clinical decision-making

Up to now, the correlation between antibody titers and clinical immunity against COVID-19 remains uncertain. Two publications describe a less frequent antibody response of transplant recipients after SARS-CoV-2 vaccination (10.8% for kidney transplant recipients and 17% for a heterogenous transplant cohort at 20 days after injection of the first dose) but as stated by the Dutch Transplant Foundation (NTS), the correlation of clinical immunity with a certain antibody titer is not yet defined. In addition, the influence of the T cell-mediated immune response remains unclear and is not necessarily correlated with SARS-CoV-2 antibody titers. Furthermore, the amplitude and duration of vaccine response as well as the duration of the response after transplantation remain to be assessed. As described above and in opposition to a strong consensus, the Chinese transplantation program demands negative antibody testing before organ retrieval.

In contrast to the clinical use of antibody testing, clinical and biological monitoring and empirical evaluation of immune response rates is defined as a crucial task by the DSO.
3.2.3 | In case of T-/ or B-cell depleting immunosuppression, a delay of 3 months until vaccination can be recommended

Consensus was found in anticipating a drastically reduced immunogenicity after T- or B-cell depletion and therefore shifting the benefit and risk of a vaccination. A delay of 3 months (AST, US) up to 6 months (ABM, France) until vaccination can thus be recommended.5,22

The AST also postulates a reduction or loss of pretransplant immunity after transplantation especially after T-/B-cell depleting immunosuppression.5 Further data are pending.

3.2.4 | A delay of 2 weeks between SARS-CoV-2 vaccination and other vaccinations can be recommended

Consensus was found for a 2-week delay between reception of a SARS-CoV-2 vaccine and other vaccinations including the seasonal influenza vaccine.14,22 The pursuit of a complete SARS-CoV-2 vaccination is to be prioritized over the influenza vaccine.

3.3 | Recommendations with low consensus (SCR C)

3.3.1 | Immunosuppression should not be suspended or reduced during the process of vaccination

Plural transplant societies recommend to maintain immunosuppression during the process of vaccination. Even though immunosuppression and especially antimetabolites may be associated with lower antibody response after vaccination,31,32 the data are widely insufficient to justify taking any risk of rejection and disturbed transplant function.

3.3.2 | After treatment of an acute rejection, a delay until vaccination can be recommended

Analogous to general vaccination recommendations, vaccination during active treatment for rejection should be avoided.26 The CST proposes a 4-week delay until SARS-CoV-2 vaccination, the Spanish Society of Transplantation at least 2 weeks.7,33

No elevated risk of rejection post-SARS-CoV-2 vaccination is to be expected. Such concerns have previously been raised especially in the context of the 2009 H1N1 influenza vaccines containing ASO3 adjuvant but were discarded by reviews.34

4 | DISCUSSION

At the present time, SARS-CoV-2 vaccination seems to be the key in controlling the SARS-CoV-2 pandemic. Once again, the high dynamic...
The current lack of evidence demands systematic scientific monitoring of safety and efficacy of performed vaccination of transplant recipients and patients awaiting transplantation.

AUTHOR CONTRIBUTIONS
Research design: Nora Nevermann and Paul Viktor Ritschl. Performance of research: Nora Nevermann, Leke Wiering, Helen Wu, Philipp Moroder, Andreas Brandl, and Paul Viktor Ritschl. Data analysis: Nora Nevermann, Brigitta Globke, Felix Krenzien, Nathanael Raschzok, Wenzel Schöning, Georg Lurje, Robert Öllinger, Moritz Schmelzle, Johann Pratschke, and Paul Viktor Ritschl. Paper writing: Nora Nevermann, Brigitta Globke, Felix Krenzien, Nathanael Raschzok, Wenzel Schöning, Georg Lurje, Robert Öllinger, Moritz Schmelzle, Johann Pratschke, and Paul Viktor Ritschl.

CONFLICT OF INTEREST
Moritz Schmelzle received funding from Merck Serono GmbH, Bayer AG, Amgen Inc., ERBE Elektromedizin GmbH, Johnson&Johnson Medical GmbH, Takeda Pharm. Lim., Olympus K.K., Medtronic GmbH, and Intuitive Surg. Inc. All other authors declare no conflict of interest.

ORCID
Nora Nevermann https://orcid.org/0000-0003-0063-9296
Paul Viktor Ritschl https://orcid.org/0000-0003-4610-1766

REFERENCES
1. Polack FP, Thomas SJ, Kitchin N, et al. Safety and efficacy of the BNT162b2 mRNA Covid-19 vaccine. N Engl J Med. 2020;383(27):2603–2615.
2. Baden LR, El Sahly HM, Essink B, et al. Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine. N Engl J Med. 2021;384(5):403–416.
3. Voysey M, Clemens SAC, Madhi SA, et al. Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK. Lancet. 2021;397(10269):99–111.
4. Ritschl PV, Nevermann N, Wiering L, et al. Solid organ transplantation programs facing lack of empiric evidence in the COVID-19 pandemic: a By-proxy Society Recommendation Consensus approach. Am J Transplant. 2020;20(7):1826–1836.
5. COVID-19 vaccine FAQ sheet. American Society of Transplantation. Accessed April 18, 2021. https://www.myastr.org/sites/default/files/2021%2003%202018%20COVID%20VACCINE%20FAQS_update.pdf
6. German Organ Transplantation Foundation. Accessed April 10, 2021. https://www.dso.de/WebsiteCollectionDocuments/News/Umgang%20mit%20Spendern%20in%20Bezug%20auf%20mögliche%20SARS-CoV-2-Infektion.pdf
7. Consensus guidance and recommendations for organ donation and transplantation services during COVID-19 pandemic. Canadian Society of Transplantation. Accessed April 15, 2021. https://profedu.blood.ca/sites/mso/files/20210224_covid_19_consensus_guidance.pdf
8. DAT3911/1.1 – Joint OTDT & BTS guidance on SARS-CoV-2 vaccination in adult solid organ and islet transplant wait-listed patients and adult living donor transplant recipients. British National Health Service. Accessed April 16, 2021. https://nhsbtbtbe.blob.core.windows.net/umbraco-assets-corp/21654/dat3911.pdf
9. Guangming L Expert consensus on the normalization of epidemic prevention and control and biosafety management in designated hospitals for novel coronavirus pneumonia carrying out liver transplantation (2020 edition). 2020. https://pesquisa.bvsalud.org/gim/resource/pt/wpr-829676
10. Transplant Infectious disease. The Transplant Society.https://tts.org/index.php?option=com_content&view=article&id=850&Itemid=140. Accessed March 3rd, 2021.
11. Caillard S, Anglicheau D, Matignon M, et al. An initial report from the French SOT COVID Registry suggests high mortality due to COVID-19 in recipients of kidney transplants. Kidney Int. 2020;98(6):1549–1558.
12. Marjot T, Webb GJ, Barritt AS, et al. SARS-CoV-2 vaccination in patients with liver disease: responding to the next big question. Lancet Gastroenterol Hepatol. 2021;6(3):156–158.
13. Ravanani R, Callaghan CJ, Mumford L, et al. SARS-CoV-2 infection and early mortality of waitlisted and solid organ transplant recipients in England: a national cohort study. Am J Transplant. 2020;20(11):3008–3018.
14. Vaccine Committee. Japan Society for Infectious Diseases COVID-19 Vaccine Recommendations (2nd edition). Japanese Transplantation Society. https://www.kansensho.or.jp/uploads/files/guidelines/2102_covid_vaccine_2.pdf. Accessed April 5th 2021.
15. Coronavirus (SARS-CoV-2) causing COVID-19: Information for donation and transplant professionals. The Transplantation Society of Australia and New Zealand. Accessed April 15, 2021. https://tsanz.com.au/storage/COVID_Communiques/OTA-TSANZ-COVID_19_Info_for_donation_and_transplantation_prof-26_Mar_2021_Version_5.pdf
16. DTG. Update on vaccinations for SOT recipients. Accessed April 26, 2021. https://www.d-t-g-online.de/index.php/covid-19
17. Boyarsky BJ, Ou MT, Greenberg RS, et al. Safety of the first dose of SARS-CoV-2 vaccination in solid organ transplant recipients. 2021;105(5):e56–e57.
18. Aslam S, Goldstein DR, Vos R, et al. COVID-19 vaccine in our transplant recipients: the time is now. J Heart Lung Transplant. 2021;40(3):169–171.
19. Boyarsky BJ, Werbel WA, Avery RK, et al. Immunogenicity of a single dose of SARS-CoV-2 messenger RNA vaccine in solid organ transplant recipients. JAMA. 2021;325(17):1784–1786.
20. Marinati S, Adamopoulos S, Degiannis D, et al. Immunogenicity of SARS-CoV-2 BNT162b2 vaccine in solid organ transplant recipients. Am J Transplant. 2021. https://doi.org/10.1111/ajt.16607.
21. Grupper A, Rabinowich L, Schwartz D, et al. Reduced humoral response to mRNA SARS-CoV-2 BNT162b2 vaccine in kidney transplant recipients without prior exposure to the virus. Am J Transplant. 2021. https://doi.org/10.1111/ajt.16615.
22. Biomedical Agency. Accessed April 06, 2021. https://www.agence-biomedecine.fr/IMG/pdf/mise_a_jour_recommandations_abm_020321-2.pdf
23. Harmala S, Parisinos CA, Shallcross L, O’Brien A, Hayward A. Effectiveness of influenza vaccines in adults with chronic liver disease: a systematic review and meta-analysis. BMJ Open. 2019;9(9):e031070.
24. Fisher KA, Bloomstone SJ, Walder J, Crawford S, Fouayzi H, Mazor KM. Attitudes toward a potential SARS-CoV-2 vaccine: a survey of U.S. adults. Ann Intern Med. 2020;173(12):964–973.
25. Gökkem R. Kidney transplantation and patients who decline SARS-CoV-2 vaccination. Accessed March 10, 2021. https://tsanz.com.au/storage/COVID_Communiques/OTA-TSANZ-COVID_19_Info_for_donation_and_transplantation_prof-26_Mar_2021_Version_5.pdf
26. Danziger-Isakov L, Kumar D, AST ID Community of Practice. Vaccination of solid organ transplant candidates and recipients: guidelines from the American Society of transplantation infectious diseases community of practice. Clin Transplant. 2019;33(9):e13563.
27. Benotmane I, Gautier-Vargass G, Cognard N, et al. Weak anti–severe acute respiratory syndrome coronavirus 2 antibody response after the
The first injection of an mRNA coronavirus disease 2019 vaccine in kidney transplant recipients. Kidney Int. 2021;99(6):1487–1489.

28. Chong PP, Avery RK. A comprehensive review of immunization practices in solid organ transplant and hematopoietic stem cell transplant recipients. Clin Ther. 2017;39(8):1581–1598.

29. COVID-19-vaccinatie van immuungecompromitteerde patiënten. Dutch Transplant Foundation. Accessed April 10, 2021. https://lci.rivm.nl/handleiding-covid-19-vaccinatie-van-immuungecompromitteerde-patiënten; COVID-19 en vaccinatiebeleid. https://www.transplantatiestichting.nl/medisch-professionals/covid-19-en-transplantaties/covid-19-en-vaccinatiebeleid

30. Sahin U, Muik A, Derhovanessian E, et al. COVID-19 vaccine BNT162b1 elicits human antibody and TH1 T cell responses. Nature. 2020;586(7830):594–599.

31. Mulley WR, Visvanathan K, Hurt AC, et al. Mycophenolate and lower graft function reduce the seroresponse of kidney transplant recipients to pandemic H1N1 vaccination. Kidney Int. 2012;82(2):212–219.

32. Suresh S, Upton J, Green M, et al. Live vaccines after pediatric solid organ transplant: proceedings of a consensus meeting. Pediatr Transplant. 2019;23(7):e13571.

33. Recomendaciones FACME para la vacunación frente a COVID-19 en grupos de potencial riesgo. Spanish Society of Transplantation. Accessed April 03, 2021. https://www.asociacionasaco.es/wp-content/uploads/2021/02/20210128-FACME-trasplante-organos-solidos-2801.pdf

34. Cohet C, Haguinet F, Dos Santos G, et al. Effect of the adjuvanted (AS03) A/H1N1 2009 pandemic influenza vaccine on the risk of rejection in solid organ transplant recipients in England: a self-controlled case series. BMJ Open. 2016;6(1):e009264.

35. Azzi Y, Bartash R, Scalea J, Loarte-Campos P, Akalin E. COVID-19 and solid organ transplantation: a review article. Transplantation. 2021;105(1):37–55.

36. Starr TN, Greaney AJ, Addetia A, et al. Prospective mapping of viral mutations that escape antibodies used to treat COVID-19. Science. 2021;371(6531):850–854.

37. Kehner J, Horton LE, Pfeffer MA, et al. SARS-CoV-2 infection after vaccination in health care workers in California. N Engl J Med. 2021;384(18):1774–1775.

How to cite this article: Nevermann N, Wiering L, Wu H, et al. Transplantation programs facing lack of empirical evidence on SARS-CoV-2 vaccination: A society recommendation consensus update. Transpl Infect Dis. 2021;23:e13696. https://doi.org/10.1111/tid.13696