

Transplantation in the Pandemic Era: Perspectives on the Utilization of COVID-19 Positive Organs

Shreya Bhasin^a, Matthew Byrne^b, Rodolfo Alpizar-Rivas^c, Mariana Chavez-Villa^d, Luis Ruffolo^b, Rafael Cisneros^a, Paritosh Prasad^c, and Karen Pineda-Solis^{d*}

^aUniversity of Rochester School of Medicine and Dentistry, Rochester, New York; ^bDepartment of Surgery, University of Rochester Medical Center, Rochester, New York; ^cDepartment of Infectious Disease, University of Rochester Medical Center, Rochester, New York; and ^dDepartment of Transplant Surgery, University of Rochester Medical Center, Rochester, New York

ABSTRACT

Background. At early stages of the pandemic, most organ procurements organizations considered COVID-19 infected donors to be ineligible for organ donation. The aim of this survey is to describe the current practices of the utilization of COVID-19 positive organs donors among American Society of Transplant Surgeons (ASTS) members.

Methods. An anonymous 40-question redcap survey was emailed to ASTS members from June to August 2022.

Results. One hundred forty-nine surveys from 10 countries were included for analysis. The majority of the responders were men (66.7%) from North America (95%) and identified as transplant surgeons (68.5%). Most work at academic institutions (76.5%). Almost all responders (94%) were willing to accept an organ from a donor with a history of COVID-19 who tested negative at the time of donation, however, there was no consensus on the length of time after the disease was resolved. Approximately 70% indicated they accept organs from asymptomatic donors with active disease. Only 32 responders indicated they would accept an organ from an individual with a history of “severe” COVID-19 infection and less than one third of the responders would accept an organ from a donor who died from COVID-19 infection. Interestingly, 80% indicated they have protocols at their institution to guide the acceptance of such organs.

Discussion. Despite new evidence that the transmission of COVID-19 in non-lung organs is extremely rare, the results of this survey suggest significant heterogeneity in practice and perceptions of the use of COVID-19 positive organs across international centers. We suggest that the implementation of a standardized protocol is of paramount importance to continue safe transplant activity.

THE world has faced a formidable challenge with the evolution of the COVID-19 pandemic, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The COVID-19 pandemic crisis has placed an immense burden on health care systems globally and has led to significant economic and social impacts, causing widespread disruptions to many aspects of the daily medical practice [1] and solid organ transplant [2–5]. The full impact of the pandemic will likely be felt for years – nonetheless, the shift toward endemic status marks a significant turning point in the global response to the COVID-19 pandemic and provides hope for a more sustainable approach to managing the virus particularly within the surgical field [6].

Unsurprisingly, the initial impact of the COVID-19 pandemic on solid organ transplant (SOT) surgery was severe and resulted in a significant reduction in the number of transplants performed globally [2–4,7–10]. This was due to various factors, such as the shortage of available organs, difficulties in identifying suitable donors, and the need to prioritize care for patients with COVID-19 [3,11]. Many transplant programs greatly decreased their activity, both in terms of donation and transplantation, to

*Address correspondence to Karen Pineda-Solis, 601 Elmwood Avenue, Box SURG/TXP, Rochester, NY 14642. E-mail: karen_pineda-solis@urmc.rochester.edu

protect both donors and recipients from potential exposure to the virus, particularly in living donor programs [12]. Programs also implemented changes in their immunosuppression regimes aimed at balancing the need to prevent transplant rejection with the need to minimize the risk of infection, particularly with SARS-CoV-2 [13–17].

In the early stages of the pandemic, most organ procurement organizations deemed SARS-CoV-2 infected donors to be ineligible for organ donation, due to a lack of information and safety concerns regarding viral transmission [18,19]. Although the respiratory tract is the most common point of entry for coronaviruses, given the immunosuppressed state of transplant recipients, there was concern that the virus could also be transmitted through blood and cause significant disease [20,21]. However, to our knowledge, there are currently no reports of hematogenous transmission of SARS-CoV-2 [22]. Research has since identified and isolated the virus from different organs, such as the heart, small intestine, and kidneys, among others raising the possibility of viremic transmission at the time of procurement. However, most of these results were under laboratory conditions with inconsistent findings [20]. Some case series have demonstrated that donor-derived SARS-CoV-2 infections occur only in lung transplant recipients and other organs for SARS-CoV-2 polymerase chain reaction (PCR) positive donors could potentially be safely used [5,22,23]. A recent systematic review found no documented cases of donor-derived infection among kidney, heart, or liver transplant recipients [22]. They also report low transmission risk of COVID-19 when using organs from donors with recent or current SARS-CoV-2 infection to non-lung recipients, even if persistently symptomatic at procurement [22].

More recent data has shown that utilizing COVID-positive organs can be safely considered and can potentially provide lifesaving transplants to patients who might otherwise have limited opportunities due to transmission concerns [21,24,25]. However, despite these encouraging results and new society recommendations, many transplant centers still do not utilize allografts from COVID-positive donors, even when the donor's COVID status is clear, and they have mild or no symptoms [19].

The aim of this survey is to provide insight into the international practice of utilizing COVID-positive organ donors among members of the American Society of Transplant Surgeons (ASTS). The findings of this study will provide important information that can inform the development of best practices and guidelines for the utilization of COVID-positive organ donors in SOT, ultimately contributing to the improvement of patient outcomes and the preservation of the integrity of the organ transplant system.

METHODS

A 40-question survey on the acceptance of donor organs in different contexts related to COVID-19 was conducted. Data were collected on Redcap. The survey was sent by email to the members of the ASTS. Email addresses were provided by the ASTS. The survey language was English. It was first sent out in June

Table 1. Summary of Survey Questions

Section	Number of Questions	Description
1	9	Demographics, title, type of practice, and number and type of organs transplanted at their institutions.
2	10	Willingness to accept organs from donors with a history of COVID-19 but negative at the time of donation.
3	9	Willingness to accept organs from donors with active asymptomatic COVID-19 at the time of donation.
4	9	Willingness to accept organs from deceased donors who died from COVID-19 pneumonia.
5	3	Changes in immunosuppression, utilization of COVID-19 positive organs in pediatric population, and donor-to-recipient transmission of COVID-19 in practice.

2022, followed by a reminder 2 weeks later, and a second reminder 2 weeks after to maximize the response rate.

The 40-question survey was structured, as shown in Table 1. Section 1 collected demographic data of the responders. Sections 2, 3, and 4 enquire about the type of organs accepted, whether there are institutional criteria or protocols at their hospitals, decision making regarding severity of the disease, vaccination status of donor and recipient, infectious disease consultation, cycle threshold in PCR testing and computed tomography (CT) scan findings.

The survey was designed to be as comprehensive as possible, while also being brief enough to ensure maximum completion rates. The questions were developed with the aim of understanding the current practices, preferences, and perceptions of transplant professionals regarding the utilization of COVID-19 positive donor organs. The results of the survey will provide valuable information on the current state of the field and will aid in the development of a standardized protocol for the utilization of COVID-19 positive donor organs in solid organ transplantation.

Ethical Considerations

Prior to data collection, all participants were informed of study purpose, the risks and benefits of participation, the principles of voluntary participation, and their right to withdraw or refuse participation at any time without any consequences. They were also informed that the collected data would be used for research purposes only.

RESULTS

One hundred eighty-nine individuals returned the survey. The last survey was answered on August 15, 2022. Of these, 40 were eliminated as only demographic data were answered. Of the remaining 149 surveys, 128 were complete and 21 were

incomplete. The latter were included because at least sections 1 and 2 were answered. Thus, 149 surveys from 10 countries were included for analysis. All data were anonymous.

SECTION 1

Most responders were men (66.7%), aged 41 to 50 years (27.9%) or 31 to 40 years (33.3%). Ninety-five percent were from America, 2.8% from Europe, and 0.6% from Asia and Australia, respectively. From the countries of North America, 66.2% were from the United States, 0.6% from Canada, and 33.1% from Mexico. From the countries of South America, one was from Costa Rica, two from Ecuador, and one from Uruguay. From Europe, there was one responder from Belgium, one from Spain and three from the United Kingdom. The responder from Asia was from Kuwait. The states that responded the most in the United States were Michigan with 13.8%, New York with 10.8%, and Massachusetts and Texas both with 9.2%. The main responders were transplant surgeons (68.5%) and trainees (10.3%). As for the type of practice, 76.5% responded that they work in an academic hospital and 18% do private practice. Approximately 40% of the responders do > 200 transplants per year, 24.6% do from 0 to 50, 15.3% from 51 to 100, 9.8% from 101 to 150, and 10.8% from 151 to 200. Eighty-six percent of the responders reported that they transplant kidneys, 61.5% liver, 39% pancreas, 4.8% heart, 5.5% small bowel, and 2.2% lungs.

Summary of results from section 1 are shown in [Table 2](#).

SECTION 2: Are you willing to accept organs from donors with a history of COVID-19 in the past but now negative?

Ninety-four percent were willing to accept an organ from donors with history of COVID-19 in the past but testing negative at time of donation. Forty-five percent referred that they were willing to accept the organ from 0 to 21 days because the donor resolved the infection, 20.0% from 21 to 90 days, and 32.9% referred no preference. The organs that responders were willing to accept in this situation were kidneys in 89.5%, liver in 72.0%, heart in 11.9%, pancreas in 39.2%, small bowel in 6.3%, and lungs in 4.2%. Eighty percent said they do have criteria or protocols at their institution or practice to guide in the acceptance of such organs.

As for the donor history of COVID-19 disease severity, 74.6% accept donors with a history of asymptomatic disease, 67.6% accept donors with a history of mild disease, 22.5% accept donors with a history of severe disease, and 21.8% do not consider the severity of the disease. Regarding the vaccination status of the donor, 83.6% accept vaccinated donors and 78.6% accept unvaccinated donors. In terms of recipient vaccination status, 97.1% accept an organ from a donor with a history of COVID-19 for a vaccinated recipient and 22.5% accept it even though the recipient is unvaccinated. Regarding infectious disease service consultation, 36.3% referred that they review all donors with a history of COVID-19 with infectious disease service (IDS), 40.7% review some donors with IDS, 16.4% do not consult IDS for any donor, and 7.1% have no

Table 2. Summary of Results from Section 1, Demographic Information of Responders

Gender	n (%)
Male	122 (66.7)
Female	61 (33.3)
Age, y	
20-30	5 (2.7)
31-40	61 (33.3)
41-50	51 (27.9)
52-60	38 (20.8)
> 62	28 (15.3)
Position	
Trainee	19 (10.3)
Transplant surgeon	126 (68.5)
Hepatologist	2 (1.1)
Nephrologist	7 (3.8)
Infectious disease	0
Other	30 (16.3)
Type of practice	
Academic	140 (76.5)
Private	33 (18)
Other	27 (14.8)
Location	
North America	168 (92.8)
Europe	5 (2.8)
South America	6 (3.3)
Asia	1 (0.6)
Australia	1 (0.6)
Which organs do you transplant? (Check all that apply.)	
Liver	112 (61.5)
Kidney	158 (86.8)
Heart	7 (3.8)
Pancreas	71 (39)
Small bowel	10 (5.5)
Lung	4 (2.2)
Other	8 (4.4)
Total volume at transplant center	
0-50	45 (24.6)
51-100	28 (15.3)
101-150	21 (11.5)
151-200	18 (9.8)
> 200	71 (38.8)

access to IDS consultation. Finally, as for the chest CT scan findings, 41.7% accept organs from donors with past COVID with noted infiltrates on CT scan, 33.8% do not accept organs from donors with past COVID with noted infiltrates on CT scan, and 32.4% do not consider chest CT scan findings in the acceptance of organs from donors with a history of COVID. Summary of results from section 2 are shown in [Table 3](#).

SECTION 3: Are you willing to accept organs from donors with active asymptomatic COVID-19 at the time of the offer? Such as a positive PCR nasopharyngeal swab or positive bronchoalveolar lavage

Of 129 people that answered this question, 92 (70.8%) were willing to accept an organ from a donor with active asymptomatic COVID-19 at the time of the offer. The organs that

Table 3. Summary of Results from Section 2

Are you willing to accept organs from donors with history of COVID-19, and now negative?	
Yes	143 (93.5%)
No	10 (6.5%)
Time since resolution of symptoms	
0-21 d	63 (45%)
21-90 d	28 (20%)
> 90 d	3 (2.1%)
No preference	46 (32.9%)
Which organs would you accept from donor with a history of COVID?	
Kidney	128 (89.5%)
Liver	103 (72%)
Heart	17 (11.9%)
Pancreas	56 (39.2%)
Small bowel	9 (6.3%)
Lung	6 (4.2%)
Combined	7 (4.9%)
Protocol in place to guide the use of previously COVID-19 positive organs	
Yes	114 (80.3%)
No	28 (19.7%)
Infection severity	
Asymptomatic	106 (74.6%)
Mild	96 (67.6%)
Severe	32 (22.5%)
Not considered	31 (21.8%)
Vaccination status	
Donor	
Vaccinated	117 (83.6%)
Unvaccinated	110 (78.6%)
Recipient	
Vaccinated	134 (97.1%)
Unvaccinated	31 (22.5%)
Infectious disease consult	
All donors with history of COVID	55 (39.3%)
Some donors with history of COVID	57 (40.7%)
No access to ID consult	10 (7.1%)
CT infiltrates	
Would accept organ	58 (41.7%)
Would not accept organ	47 (33.8%)
Do not consider CT findings	45 (32.4%)

CT, computed tomography.

responders were willing to accept in this situation were kidneys in 87%, liver in 75%, heart in 5.4%, pancreas in 31.5%, small bowel in 4.3%, and lungs in 2.2%. Of the persons that answered that were willing to accept the offer in this circumstance, 77.8% referred they do have criteria or protocols at their institution or practice to guide in the acceptance of such organs.

As for the vaccination status of the donor, 92.9% accept vaccinated donors and 73.8% accept also unvaccinated donors. In terms of recipient vaccination status, 97.6% accept an organ from a donor with active asymptomatic COVID-19 for a vaccinated recipient and 18.3% accept it even though the recipient is unvaccinated. Regarding the infectious disease service consultation, 45.2% referred that they review all donors with active asymptomatic COVID-19 with IDS, 34.1% review some donors with IDS, 16.7% do not consult IDS for any donor, and 6.3%

have no access to IDS consultation. Regarding the cycle threshold in PCR testing consideration to accept organs in this situation, 44.0% mentioned that they accept organs from active asymptomatic COVID donors with high cycle threshold result, 29.6% referred that they do not accept organs with a high cycle threshold result, and 29.6% mentioned that they do not consider the cycle threshold result in their acceptance of such organs. Finally, as for the chest CT scan findings, 38% accept organs from donors with active asymptomatic COVID-19 with noted infiltrates on CT scan, 33.9% do not accept organs from donors with active asymptomatic COVID-19 with noted infiltrates on CT scan, and 22.2% do not consider chest CT scan findings in the acceptance of organs from donors with active asymptomatic COVID-19. Summary of the results from section 3 are shown in [Table 4](#).

SECTION 4: Are you willing to accept organs from donors that died from COVID-19 pneumonia?

Of 123 persons that answered this question, 34 (27.4%) were willing to accept an organ from a donor who had died of COVID-19 pneumonia. The organs that the responders were willing to accept in this situation were kidneys in 72.7%, liver in 81.8%, heart in 9.1%, pancreas in 27.3%, small bowel in 9.1%, and lungs in 9.1%. Of the persons that answered that were willing to accept the offer in this circumstance, 76.5% referred they do have criteria or protocols at their institution or practice to guide in the acceptance of such organs.

In relation to the presence of COVID-19 inflammatory or thrombotic syndrome, 11.8% referred that they were willing to accept organs from donors that had an inflammatory or thrombotic syndrome. As for the donor history of COVID-19 disease

Table 4. Summary of Results from Section 3

Willing to accept organs from donor who is COVID-19 positive?	
Yes	92 (70.8%)
No	38 (29.2%)
Which organs would you accept from an asymptomatic, COVID-19 positive donor?	
Kidney	80 (87%)
Liver	69 (75%)
Heart	5 (5.4%)
Pancreas	29 (31.5%)
Small bowel	4 (4.3%)
Lung	2 (2.2%)
Combined	2 (2.2%)
Protocol in place to guide the use of previously COVID-19 positive organs	
Yes	70 (77.8%)
No	20 (22.2%)
Vaccination status	
Donor	
Vaccinated	117 (92.9%)
Unvaccinated	93 (73.8%)
Recipient	
Vaccinated	123 (97.6%)
Unvaccinated	23 (18.3%)

severity, 69.6% accept donors with history of mild disease, 23.2% accept donors with history of severe disease, and 28.6% do not consider the severity of the disease. Regarding the vaccination status of the donor, 92.4% accept vaccinated donors and 68.6% accept also unvaccinated donors. In terms of recipient vaccination status, 99% accept an organ from a donor who had died of COVID-19 pneumonia for a vaccinated recipient and 22.1% accept it even though the recipient is unvaccinated.

Regarding the IDS consultation, 42.1% referred that they review all donors who had died of COVID-19 pneumonia with IDS, 35.5% review some donors with IDS, 16.8% do not consult IDS for any donor, and 8.4% have no access to IDS consultation. Regarding the cycle threshold in PCR testing consideration to accept organs in this situation, 44.3% mentioned that they accept organs from donors who had died of COVID-19 pneumonia with high cycle threshold result, 27.4% referred that they do not accept organs with a high cycle threshold result, and 32.1% mentioned that they do not consider the cycle threshold result in their acceptance of such organs. Finally, as for the chest CT scan findings, 37.1% accept organs from donors who had died of COVID-19 pneumonia with noted infiltrates on CT scan, 36.2% do not accept organs with noted infiltrates on CT scan, and 32.4% do not consider chest CT scan findings in the acceptance of organs from donors who had died of COVID-19 pneumonia. Summary of the results from section 4 are shown in Table 5.

SECTION 5

Of 117 people that answered this section, 14 (11.9%) mentioned that they recommend a change in the immunosuppression protocol for those organs affected by COVID-19. Eighteen

percent of the respondents mentioned they also perform pediatric transplants of organs from donors affected by COVID-19 and 95.2% of them consider similar criteria for pediatric transplants in these circumstances. Finally, 10 respondents (8.5%) mentioned that they have seen COVID-19 transmission in their recipients.

DISCUSSION

The global COVID-19 pandemic has brought about unprecedented changes in the world of transplantation. End-stage organ failure remains a major cause of death worldwide, and the gap between the number of donors and recipients continues to widen. At the start of the pandemic, the transplant community faced a decrease in transplant activity due to the high mortality rates observed in recipients of SOTs, with reports of up to 50% mortality in unvaccinated patients [26,27].

One of the major concerns among the transplant community was the potential transmission of COVID-19 through organ donors. Health authorities provided guidance to transplant programs, but this guidance was widely varied across programs and the world. Initially, international and organ procurement organizations recommended screening for COVID-19 and advised against the use of positive COVID-19 donors in transplantation [18,19]. In an effort to reduce the likelihood of donor-derived infection, most international transplant societies recommended a routine COVID-19 PCR test for all solid organ donors. The use of COVID-19 positive donors was discouraged, and donors with a positive test or a history of COVID-19 were considered for transplantation only after complete clinical recovery and a recent negative PCR [19,27].

This survey was conducted to better understand the current opinions of transplant professionals on the utilization of COVID-19 positive organs and the pathways to maintain transplant activity safely. The survey collected responses from all transplant team members, including surgeons, hepatologists, nephrologists, trainees, and other specialists from three continents. Most respondents were experienced specialists who worked at academic centers with a high volume of cases per year (> 100 transplants per year). The results of the survey showed that the majority of responders agreed that they would accept organs from donors with a history of COVID-19 who are currently negative. However, there was no consensus on the specific time frame after the resolution of the disease, with responses heterogeneous. Most responders had a protocol in place at their institution, and the results of the survey demonstrate that the transmission of COVID-19 through solid organ transplantation is extremely rare.

The results also showed that most responders were willing to accept organs from patients with a history of mild or asymptomatic COVID-19, but only 32 of the responders felt comfortable accepting organs from patients with a history of severe COVID-19, even if they tested negative at the time of donation. Similarly, only 34 responders would accept organs from donors that died of COVID-19 pneumonia. Thus, despite the current evidence that the risk of COVID-19 transmission from donor to recipient is low, and that most international societies do

Table 5. Summary of Results from Section 4

Willing to accept organs from donor who died from COVID-19?	
Yes	34 (27.4%)
No	90 (72.6%)
Which organs would you accept from an asymptomatic, COVID-19 positive donor?	
Kidney	8 (72.7%)
Liver	9 (91.8%)
Heart	1 (9.1%)
Pancreas	3 (27.3%)
Small bowel	1 (9.1%)
Lung	1 (9.1%)
Combined	0
Protocol in place to guide the use of previously COVID-19 positive organs	
Yes	26 (76.5%)
No	8 (23.5%)
Vaccination status	
Donor	
Vaccinated	91 (92.4%)
Unvaccinated	72 (68.6%)
Recipient	
Vaccinated	103 (99%)
Unvaccinated	23 (22.1%)

cautiously sanction the use of such organs, this is not represented in clinical practice. Further, it demonstrates that organs that might be safe and viable for transplant are not being used given clinical doubt and uncertainty surrounding COVID-19.

This highlights the need for further research and the development of standardized protocols around the use of COVID-19 positive organs in transplantation. Furthermore, it may be beneficial to encourage institution-specific discussions within transplant teams to enhance physician confidence in the guidelines and ensure appropriate donor utilization. With the increasing number of COVID-19 cases worldwide, it is crucial to establish a clear and evidence-based approach to ensure the safe and effective utilization of COVID-19 positive organs in transplantation.

Limitations

Whereas our study attempted to collect global data, most responders were from the United States. This was an expected result as we sent our survey to members of ASTS, who are mostly from the United States. Additionally, our survey questions were designed to gather a comprehensive understanding of current practices, and we acknowledge that there are many intricacies that are typically assessed on a case-by-case basis. Future studies should aim to examine in greater detail the specific attributes of donor history that physicians utilize to inform their decision making process.

CONCLUSION

In conclusion, the results of this survey demonstrate the importance of standardizing protocols around the use of COVID-19 positive organs in transplantation. Whereas international transplant guidelines continue to emphasize the low risk of COVID-19 transmission from non-lung and intestinal organs, physicians and individual institutions may not be utilizing all available organs due to persistent concerns regarding the safety of these organs. Given the global shortage of available organs, it is crucial to ensure that safe and effective transplant practices are maintained, while also considering the evolving understanding of COVID-19 transmission and its impact on transplant recipients.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHOR CONTRIBUTIONS

Shreya Bhasin: Performed research, data analysis, and manuscript preparation. **Matthew Byrne:** Performed data analysis, manuscript preparation, and critical revisions. **Rodolfo Alpi-zar-Rivas:** Participated in research design, data analysis, and manuscript preparation. **Mariana Chavez-Villa:** Performed research, data analysis, and manuscript preparation. **Luis**

Ruffolo: Performed research. **Rafael Cisneros:** Performed the research. **Paritosh Prasad:** Performed the research. **Karen Pineda-Solis:** Established research design, performed the research, data analysis, and manuscript preparation.

FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ACKNOWLEDGMENTS

No additional acknowledgments.

REFERENCES

- [1] Mattingly AS, Rose L, Eddington HS, Trickey AW, Cullen MR, Morris AM, et al. Trends in US surgical procedures and health care system response to policies curtailing elective surgical operations during the COVID-19 pandemic. *JAMA Netw Open* 2021;4(12): e2138038. doi: [10.1001/jamanetworkopen.2021.38038](https://doi.org/10.1001/jamanetworkopen.2021.38038).
- [2] Legeai C, Savoye E, Cantrelle C, Jasseron C, Santin G, Brousse G, et al. Impact of COVID-19 on 2020 transplant activity and waiting lists in France. *J Liver Transplant* 2022;5:100051. doi: [10.1016/j.liver.2021.100051](https://doi.org/10.1016/j.liver.2021.100051).
- [3] Manara AR, Mumford L, Callaghan CJ, Ravanian R, Gardiner D. Donation and transplantation activity in the UK during the COVID-19 lockdown. *Lancet Lond Engl* 2020;396(10249):465–6. doi: [10.1016/S0140-6736\(20\)31692-5](https://doi.org/10.1016/S0140-6736(20)31692-5).
- [4] Danziger-Isakov L, Blumberg EA, Manuel O, Sester M. Impact of COVID-19 in solid organ transplant recipients. *Am J Transplant* 2021;21(3):925–37. doi: [10.1111/ajt.16449](https://doi.org/10.1111/ajt.16449).
- [5] Bartelt L, van Duin D. An overview of COVID-19 in solid organ transplantation. *Clin Microbiol Infect Off Publ Eur Soc Clin Microbiol Infect Dis* 2022;28(6):779–84. doi: [10.1016/j.cmi.2022.02.005](https://doi.org/10.1016/j.cmi.2022.02.005).
- [6] Antia R, Halloran ME. Transition to endemicity: understanding COVID-19. *Immunity* 2021;54(10):2172–6. doi: [10.1016/j.immuni.2021.09.019](https://doi.org/10.1016/j.immuni.2021.09.019).
- [7] de Vries APJ, Alwayn IPJ, Hoek RAS, van den Berg AP, Ultee FCW, Vogelaar SM, et al. Immediate impact of COVID-19 on transplant activity in the Netherlands. *Transpl Immunol* 2020;61:101304. doi: [10.1016/j.trim.2020.101304](https://doi.org/10.1016/j.trim.2020.101304).
- [8] Domínguez-Gil B, Coll E, Fernández-Ruiz M, Corral E, Del Río F, Zaragoza R, et al. COVID-19 in Spain: transplantation in the midst of the pandemic. *Am J Transplant* 2020;20(9):2593–8. doi: [10.1111/ajt.15983](https://doi.org/10.1111/ajt.15983).
- [9] Loupy A, Aubert O, Reese PP, Bastien O, Bayer F, Jacquelinet C. Organ procurement and transplantation during the COVID-19 pandemic. *Lancet Lond Engl* 2020;395(10237):e95–6. doi: [10.1016/S0140-6736\(20\)31040-0](https://doi.org/10.1016/S0140-6736(20)31040-0).
- [10] Angelico R, Trapani S, Manzia TM, Lombardini L, Tisone G, Cardillo M. The COVID-19 outbreak in Italy: initial implications for organ transplantation programs. *Am J Transplant* 2020;20(7):1780–4. doi: [10.1111/ajt.15904](https://doi.org/10.1111/ajt.15904).
- [11] Kute VB, Fleetwood VA, Meshram HS, Guenette A, Lentine KL. Use of organs from SARS-CoV-2 infected donors: is it safe? A contemporary review. *Curr Transplant Rep* 2021;8(4):281–92. doi: [10.1007/s40472-021-00343-0](https://doi.org/10.1007/s40472-021-00343-0).
- [12] Ahn C, Amer H, Anglicheau D, Ascher NL, Baan CC, Battsetset G, et al. Global Transplantation COVID Report March 2020. *Transplantation* 2020;104(10):1974–83. doi: [10.1097/TP.0000000000003258](https://doi.org/10.1097/TP.0000000000003258).
- [13] Raja MA, Mendoza MA, Villavicencio A, Anjan S, Reynolds JM, Kittipibul V, et al. COVID-19 in solid organ transplant recipients: a systematic review and meta-analysis of current literature. *Transplant Rev* 2021;35(1):100588. doi: [10.1016/j.trre.2020.100588](https://doi.org/10.1016/j.trre.2020.100588).

- [14] Bae S, McAdams-DeMarco MA, Massie AB, Ahn JB, Werbel WA, Brennan DC, et al. Early changes in kidney transplant immunosuppression regimens during the COVID-19 pandemic. *Transplantation* 2021;105(1):170–6. doi: [10.1097/TP.0000000000003502](https://doi.org/10.1097/TP.0000000000003502).
- [15] Heldman MR, Kates OS, Fisher CE, Limaye AP. Immunosuppression in solid organ transplant recipients with Covid-19: more data, but still complicated. *Transpl Infect Dis Off J Transplant Soc* 2021;23(4):e13650. doi: [10.1111/tid.13650](https://doi.org/10.1111/tid.13650).
- [16] Bordes SJ, Montorfano L, West-Ortiz W, Valera R, Cracco A, Alonso M, et al. Trends in US kidney transplantation during the COVID-19 pandemic. *Cureus* 2020;12(12):e12075. doi: [10.7759/cureus.12075](https://doi.org/10.7759/cureus.12075).
- [17] Di Maira T, Berenguer M. COVID-19 and liver transplantation. *Nat Rev Gastroenterol Hepatol* 2020;17(9):526–8. doi: [10.1038/s41575-020-0347-z](https://doi.org/10.1038/s41575-020-0347-z).
- [18] Kumar D, Manuel O, Natori Y, Egawa H, Grossi P, Han SH, et al. COVID-19: a global transplant perspective on successfully navigating a pandemic. *Am J Transplant* 2020;20(7):1773–9. doi: [10.1111/ajt.15876](https://doi.org/10.1111/ajt.15876).
- [19] Nevermann N, Wiering L, Wu H, Moroder P, Brandl A, Globke B, et al. Transplantation programs facing lack of empirical evidence on SARS-CoV-2 vaccination: A society recommendation consensus update. *Transpl Infect Dis* 2021;23(4):e13696. doi: [10.1111/tid.13696](https://doi.org/10.1111/tid.13696).
- [20] Gaussen A, Hornby L, Rockl G, O'Brien S, Delage G, Sapir-Pichhadze R, et al. Evidence of SARS-CoV-2 infection in cells, tissues, and organs and the risk of transmission through transplantation. *Transplantation* 2021;105(7):1405–22. doi: [10.1097/TP.0000000000003744](https://doi.org/10.1097/TP.0000000000003744).
- [21] Kates OS, Fisher CE, Rakita RM, Reyes JD, Limaye AP. Use of SARS-CoV-2-infected deceased organ donors: should we always “just say no”? *Am J Transplant* 2020;20(7):1787–94. doi: [10.1111/ajt.16000](https://doi.org/10.1111/ajt.16000).
- [22] Martinez-Reviejo R, Tejada S, Cipriano A, Karakoc HN, Manuel O, Rello J. Solid organ transplantation from donors with recent or current SARS-CoV-2 infection: a systematic review. *Anaesth Crit Care Pain Med* 2022;41(4):101098. doi: [10.1016/j.accpm.2022.101098](https://doi.org/10.1016/j.accpm.2022.101098).
- [23] Kaul DR, Valesano AL, Petrie JG, et al. Donor to recipient transmission of SARS-CoV-2 by lung transplantation despite negative donor upper respiratory tract testing. *Am J Transplant* 2021;21(8):2885–9. doi: [10.1111/ajt.16532](https://doi.org/10.1111/ajt.16532).
- [24] Bock MJ, Vaughn GR, Chau P, Berumen JA, Nigro JJ, Ingulli EG. Organ transplantation using COVID-19-positive deceased donors. *Am J Transplant* 2022;22(9):2203–16. doi: [10.1111/ajt.17145](https://doi.org/10.1111/ajt.17145).
- [25] Koval CE, Poggio ED, Lin Y, Kerr H, Eltemamy M, Wee A. Early success transplanting kidneys from donors with new SARS-CoV-2 RNA positivity: a report of 10 cases. *Am J Transplant* 2021;21(11):3743–9. doi: [10.1111/ajt.16765](https://doi.org/10.1111/ajt.16765).
- [26] 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. doi: [10.1097/TP.0000000000003523](https://doi.org/10.1097/TP.0000000000003523).
- [27] Boan P, Marinelli T, Opdam H. Solid organ transplantation from donors with COVID-19 infection. *Transplantation* 2022;106(4):693–5. doi: [10.1097/TP.0000000000004074](https://doi.org/10.1097/TP.0000000000004074).