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# Effects of the COVID-19 Pandemic on Solid Organ Transplantation During 2020 in Poland Compared with Countries in Western Europe, Asia, and North America: A Review

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The coronavirus disease 2019 (COVID-19) pandemic, due to infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which began in March 2020, affected organ donor acceptance and rates of heart, lung, kidney, and liver transplants worldwide. According to data reported to POLTRANSPLANT, the number of solid organ transplants decreased by over 35% and the number of patients enlisted de novo for organ transplantation was reduced to 70% of its pre-COVID-19 volume in Poland. Most transplant centers in Western Europe and the USA have also drastically reduced their activity when compared to the pre-pandemic era. Areas of high SARS-CoV-2 infection incidence, like Italy, Spain, and France, were most affected. Significant decreases in organ donation and number of transplant procedures and increase in waitlist deaths have been noted due to overload of the healthcare system as well as uncertainty of donor SARS-CoV-2 status. Intensive care unit bed shortages and less intensive care resources available for donor management are major factors limiting access to organ procurement. The impact of the COVID-19 outbreak on transplant activities was not so adverse in Asia, as a result of a strategy based on experience gained during a previous SARS pandemic. This review aims to compare the effects of the COVID-19 pandemic on solid organ transplantation during 2020 in Poland with countries in Western Europe, North America, and Asia.

**Keywords:** COVID-19 • Organ Transplantation • Pandemics • Transplants

**Abbreviations:** AASLD – American Association for the Study of Liver Diseases; ARDS – acute respiratory distress syndrome; AST – American Society of Transplantation; AZA – azathioprine; CDC – Centers for Disease Control and Prevention; CNI – calcineurin inhibitor; COVID-19 – Coronavirus Disease 2019; ELITA – European Liver and Intestine Transplantation Association; ELTR – European Liver Transplant Registry; HT – heart transplant; ICU – Intensive Care Unit; LDKT – living donor kidney transplantation; LT – liver transplantation; MERS – Middle-East Respiratory Syndrome; MPA – mycophenolic; mTORI – mTOR inhibitors; PCR – polymerase chain reaction; RT-PCR – reverse transcription polymerase chain reaction; SARS-CoV-2 – severe acute respiratory syndrome coronavirus type 2; UNOS – United Network for Organ Sharing; WHO – World Health Organization

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## Background

Since December 2019, when the numbers of patients with diagnosis of unknown pneumonia were first reported in the city of Wuhan, China, a novel pathogen has dramatically impacted almost every aspect of life worldwide. It was identified as a new Betacoronavirus and named severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2) [1]. Symptomatic infection caused by SARS-CoV-2 has been named coronavirus disease 2019 (COVID-19). The World Health Organization (WHO) officially declared the COVID-19 outbreak a global pandemic in March 2020 [2]. In the months that followed, the number of affected countries and the number of infected cases have rapidly climbed as a result of the virus's infectiousness and wide spread, with each individual estimated to infect 1 to 3 other people [3]. At the end of January 2021, there have been more than 97 000 000 confirmed cases of SARS-CoV-2 infection (including 2 100 000 deaths) reported to the WHO in 221 countries throughout the world [4].

The overwhelming burden of the COVID-19 pandemic for healthcare systems has affected all aspects of medical practices. Several reports demonstrated significant decreases in solid organ donation and transplantation worldwide secondary to the ongoing COVID-19 pandemic [5-7]. Most transplant centers drastically reduced their activity. This effect was particularly profound in the areas of high incidence of COVID-19 infection, due to intensive care unit (ICU) bed shortage from growing numbers of COVID-19 patients in need of intensive therapy [7,8]. Overwhelmed healthcare systems resulted in reduced capacity of intensive care units as a consequence of occupation by patients with COVID-19-related respiratory failure. The limited number of neurocritical patient admissions resulted in reduced reporting of potential donors to the transplant coordination teams. There was also a reduced number of donations due to logistics and/or uncertainty about donor SARS-CoV-2 status. Many of them test positive for SARS-CoV-2 and are lost to organ procurement [9,10].

Organ transplantation, as a therapy of end-stage heart, lung, or liver failure, is a life-saving treatment comparable to management of oncological and heart diseases. Whatever the global situation is, they must not be limited. Solid organ transplantation programs are currently facing multiple challenges because of the global COVID-19 outbreak. Minimizing risks to both patients and healthcare workers during the COVID-19 pandemic remains a major concern. The aim is to avoid use of infected donors, to not admit potentially infected transplant candidates, and to not transplant currently hospitalized infected candidates. Numerous recommendations have been made to improve the situation [11-16]. Several transplant societies developed expert guidelines regarding all stages of the transplant procedure (donor and recipient selection, pre-transplant

management, surgery itself, and posttransplant and long-term care) in the context of the pandemic [10,17]. The evaluation of SARS-CoV-2 infection for both donors and recipients is commonly considered essential.

A strong consensus was found for donor exposure evaluation including history of travel to high-risk areas and known contact with suspected/confirmed COVID-19 within 14 days (or even 21 days) of possible donation [17-19]. The second part of the evaluation includes the assessment of donor clinical risk of being infected. It contains of medical history (presence of lower-respiratory tract infection symptoms, fever, anosmia), SARS-CoV-2 reverse transcription polymerase chain reaction (RT-PCR) testing with nasopharyngeal swab (or lower-respiratory tract sample obtained via bronchoscopy) and imaging modalities [19]. According to the American Society of Transplantation (AST), testing of at least 1 sample for the virus should be performed within 72 hours prior to organ procurement, with another test 12-24 hours later (within 24-48 hours of procurement) additionally recommended by some experts whenever possible [10]. Nasopharyngeal swab is a preferred option to obtain upper respiratory tract specimens for SARS-CoV-2 detection, followed by mid-turbinate, anterior nasal, and oropharyngeal specimens [13,20]. As a consequence of its limited sensitivity (accounting for 62-78% for nasopharyngeal swab RT-PCR tests) [21], radiographic imaging of the chest for both potential donors and transplant candidates are performed. Noncontrast computed tomography (CT) is recommended instead of a chest X-ray to improve sensitivity (up to 97% for those suspected of having COVID-19) [19,22]. There is a strong recommendation to reject any symptomatic potential donor [19]. The Transplant Infectious Disease Section of the Transplantation Society recommends to exclude from donation all deceased with unexplained respiratory failure [18]. Only asymptomatic donors may be accepted if they are negative for SARS-CoV-2 RT-PCR and CT [17,23]. According to AST guidelines, COVID-19 convalescent candidates must have a grace period of 28 days from resolution of symptoms [1] and have 2 negative SARS-CoV-2 RT-PCR tests at least 1 week apart and clear chest CT imaging prior to being reconsidered for donation [17].

No solid organ transplant procedures performed on COVID-19 patients have been reported so far. Therefore, the expected negative impact on outcome remains speculative. However, it is widely recommended to rule out any possible recipient infection before transplant. Asymptomatic candidates may be considered for transplantation if they are SARS-CoV-2 RT-PCR-negative with CT chest scan showing no symptoms of COVID-19. Exposure to a person under investigation in the previous 21 days (or with confirmed COVID-19 in the last 28 days) calls for a delay of the transplant procedure [17]. Until now, no report on the duration of symptom resolution prior

to transplantation in a previously COVID-19 positive recipient has been published.

The prolonged time needed for testing potential donors and recipients causes additional organizational and logistical problems. The availability of COVID-free hospital facilities, and human resources in transplant teams were periodically limited due to cases among healthcare professionals or their quarantine. Transplant teams are frequently declining organ offers after an individual risk assessment considering the clinical situation of potential recipients on the waiting list and limited COVID-19-free areas available in the hospital. Therefore, mortality on the waiting list remains a collateral damage of the COVID-19 pandemic. Taking into account intensive care beds, ventilators, and trained staff availability prior to organ acceptance is a strong recommendation of more than half of transplant societies [19]. The risk of SARS-CoV-19 transmission through surgical explant teams related with a high-contact profile work and the mobility of medical staff associated with organ procurement and transplantation procedures should also be considered. The Korean Transplant Society and the British National Health Service recommend screening explant teams for SARS-CoV-2 infection, including clinical and temperature control before entering the organ donor hospital. The Hungarian government prohibited foreign explant teams from entering the country [19].

The majority of transplant-focused societies recommend that immunosuppressed solid organ transplant patients strictly follow general preventive restrictions concerning hygiene and life-style, and the same pertains to their household cohabitants [19]. Half of transplant societies recommend to postpone nonessential transplant clinic visits, person-to-person interventions, and diagnostics to reduce interpersonal contacts and replace them with telemedicine. Transplant patients are recommended to be provided with a 90-day medication supply in case of unexpected delay or quarantine [19,24].

A multicenter cohort study was performed by Kates et al to analyze the clinical manifestations of COVID-19 in solid organ transplant recipients [25]. A survey included 482 SOT recipients (median age 58) from over 50 transplant centers: 78% of them were admitted to a hospital in the course of disease, half of them to an Intensive Care Unit (ICU); one-third required mechanical ventilation, and the mortality rate was 18.7% among the cohort and 20.5% in hospitalized patients. The spectrum of the disease severity was generally consistent with that of the general population [10]; however, weakened or atypical clinical presentation of COVID-19 in the immunocompromised population was also reported [17]. Raja et al conducted a systematic review and meta-analysis of solid organ transplant (SOT) recipients with COVID-19 [26]. The most common symptoms observed were fever and cough in 70.2% and 63.8%, respectively.

A high incidence of hospital admission (81%) in SOT recipients with SARS-CoV-2 infection was noted and almost 30% of them required admission to an ICU. The overall mortality rate was 18.6% in their study. Compared to the general population, viral shedding may be prolonged in transplant recipients (21 vs 14 days) [10,27,28]. Immunocompetent people clear the virus in nasopharyngeal swabs within approximately 2 weeks after symptom onset, but it takes more time in immunocompromised organ recipients [29]. Comorbidities, including older age, heart failure, chronic lung disease, and obesity, were independently associated with mortality [25]. Immunosuppression intensity was not associated with mortality. Concerns about the disproportionately severe impact of COVID-19 in SOT recipients related to immunosuppression were not confirmed. If there is no individual history of rejection episodes, reduction of immunosuppression may be considered for transplant patients with symptomatic COVID-19 in accordance with transplant societies consensus [19]. Nevertheless, D'Antiga published an analysis of clinical observations in SARS-CoV-2-positive transplant recipients and suggested that infection does not lead to a more severe course of disease in immunosuppressed patients, in contrast to other common viral agents (eg, adenovirus, influenza, respiratory syncytial virus) [30].

This review aims to summarize the effects of the COVID-19 pandemic on solid organ transplantation during 2020 in Poland. The effects of the COVID-19 pandemic and SARS-CoV-2 infection will be discussed in terms of organ donation, screening of donors and recipients for SARS-CoV-2, and the number of solid organ transplants, with a discussion of the recent clinical guidelines.

## COVID-19 and Transplantation in Poland

According to data reported to POLTRANSPLANT, the Organization and Coordination Center for Transplantation in Poland, which includes a central registry of organ refusals, the number of solid organ transplantation procedures declined in Poland [31]. During 10 months of the pandemic (the first SARS-CoV-2 infected case was diagnosed on March 4<sup>th</sup>, 2020), the monthly number of deceased organ donors decreased to 58% of its pre-pandemic value. From March to December 2020, it fell to an average of 24 per month, compared to 42 between November 2019 and February 2020. A 43% decline in potential donor reporting was observed. The rate of medical disqualification from procurement increased from 11% to 13%. As a result, the number of all solid organ transplants tumbled to 64% of the pre-COVID-19 era (deceased donor kidney – 60%; living donor kidney – 63%; deceased donor liver – 63%). No reduction of the heart (126%), lung (100%), or living donor liver transplants (183%) was observed due to less stringent donor acceptance criteria. The number of patients enlisted de novo

for organ transplantation decreased significantly to 70% of its normal volume (including kidney – 60%; liver – 82%; heart – 76%) [31]. The possibility of donor-derived SARS-CoV-2 transmission, and the risk of asymptomatic SARS-CoV-2 infection in a potential recipient prior to transplantation, are the factors most contributing to the slowdown [32,33].

In accordance with POLTRANSPLANT recommendations [31], RT-PCR testing for SARS-CoV-2 RNA with using a throat swab, nasal swab, or in most cases, both, is mandatory for potential organ donors, and donation is abandoned when the test result is positive. A negative result of the gene test (performed not earlier than 72 hours) and a chest CT scan negative for COVID-19 typical changes precede organ and tissue donation and transplantation. For COVID-19 convalescents, organ donation is allowed at least 28 days after the end of the isolation period. Clinical and epidemiological testing of the potential organ recipient is mandatory before transplantation procedures. POLTRANSPLANT mandates performance of gene or antigen tests, and recommends a chest CT scan in all recipients immediately prior to transplantation. In addition, informed consent regarding the possibility of SARS-CoV-2 transmission has to be given before proceeding with the transplant. During the second wave of the pandemic, recruitment of organ donors and organ procurement was suspended in multidisciplinary hospital centers constituting the highest level of the hospital system for patients with COVID-19 as well as other departments temporarily closed for risk of nosocomial SARS-CoV-2 infections [31].

Since the first mRNA vaccines have been globally approved, great hope is placed in vaccinations against COVID-19. As it is not a live vaccine, immunocompromised patients are not exposed to any additional risk. Additionally, the researchers say, organ rejection, which is a common concern in vaccinating transplant recipients, did not occur [34]. According to the WHO, full vaccination is recommended to both immunocompromised organ recipients and those waitlisted for transplant [31]. As immunocompromised patients were not included in clinical trials of vaccines, there is insufficient data available to assess vaccine efficacy and risk in patients with severe immunosuppression. Immune response to the vaccine may be altered, resulting in reduction of effectiveness [35,36]. In order to be vaccinated, an immune status after organ transplant has to be aligned and stable, with the immunosuppressive agents taken in a maintenance dosage. Vaccination against COVID-19 is recommended by POLTRANSPLANT no sooner than 1 month after the transplantation procedures, and 3-6 months later if lymphocyte-depleting therapy was induced. Immunocompromised transplant recipients, as well as those who are waitlisted, are also recommended to receive seasonal influenza vaccination. The need for vaccination of medical staff involved in transplant procedures is obvious [31].

## COVID-19 and Transplantation in Western Europe

The impact of the pandemic on regional transplant programs significantly depends on the national society's approach in handling COVID-19 as well as governmental regulations on social distancing, lockdown policy, and recommendations, which affect community spread of the disease. Italy was the first Western country to face the COVID-19 pandemic. A national survey performed by Vistoli et al documented that most transplant centers have drastically diminished their activities, especially in living-related transplants [37], mostly reported in the areas with high incidence of COVID-19. Almost all transplant recipients who tested positive for SARS-CoV-2 required hospitalization, one-quarter of them had to be admitted to an ICU, and 1 in 6 died. However, successful heart transplantation in SARS-CoV-2-negative recipients with no unexpected posttransplant infections in northern Italy are also shown in single-center reports [38].

Spain has been the world leader in organ donation and transplantation so far, with the all-time records in both total number of donors and number of solid organ transplants. At the same time, Spain was one of the European countries most affected by COVID-19, with a mortality rate of 11.3% [7]. Dominguez Gil et al reported a decline in the mean number of donors from 7.2 to 1.2 per day and the mean number of transplants from 16.1 to 2.1 per day [7].

A decrease in the overall number of solid organ procurements and transplantations was also observed in France (up to 90%). A strong temporal association between the increase in COVID-19 cases and reduction in transplantation procedures was noted. Kidney transplant programs were most affected; however, a substantial effect was also seen for heart, lung, and liver transplants. Transplantation rates were significantly reduced even in regions with lower COVID-19 prevalence, suggesting a global and nationwide effect of the outbreak [6].

According to data from the United Kingdom transplant registry, the overall number of kidney donations and transplantations decreased by over two-thirds because of the COVID-19 pandemic (deceased donor – 69.5%, living donor – 87%). Most transplant centers suspended their activities during the peak of the pandemic for safety issues as well as the ICU bed shortage. The mortality rate among SARS-CoV-2-positive candidates for transplant was 10.2% [5]. However, as Georgiades et al reported [5], transplant outcomes remained similar, with no difference in the rates of delayed graft function, acute rejection, reoperation, or length of hospital stay during the pandemic compared to the pre-pandemic era, and no serious sequelae of COVID-19 among transplant recipients were noticed.

The COVID-19 pandemic has had a significant impact on liver transplantation programs in Europe. Most liver transplantation centers restricted activity to most urgent cases. The European Liver and Intestine Transplantation Association (ELITA) performed an Internet-based survey among transplant centers affiliated with the European Liver Transplant Registry (ELTR) to estimate the frequency of COVID-19 in liver transplant (LT) patients across Europe [39]. It showed that liver transplant candidates and recipients are at higher risk of severe course of the disease. The incidence of symptomatic COVID-19 is significantly higher in those who are waitlisted (1.05% ranging from 0.5% to 20% among the centers) than in those who are transplanted (0.3%, ranging from 0.1% to 5%), and it was also significantly higher among LT candidates and not different among recipients when compared with the general population. The rate of admissions to ICUs related to COVID-19 was similar in both groups, at 14%. Mortality rates among LT candidates and LT recipients did not vary significantly (18% and 15%, respectively); however, it was 8% among the general adult population. The distribution of cases across countries was unequal and it was significantly higher in Italy, France, and Spain, where it constituted 74% of the total reported cases.

In contrast, transplant activities in Germany during the COVID-19 pandemic had no significant reduction. Overall number of kidney transplants were stable, while the numbers of heart, lung, and liver transplantations from deceased donors increased in the first months of 2021 compared to the previous year. It is thought to be related to adequate intensive care resources allocated to organ procurement and transplantation and benefits from the control strategy against COVID-19 in Germany. Living donation programs were only temporarily postponed, and deceased organ donor transplants continued constantly [40].

A retrospective review of transplant recipients performed by Elec et al analyzed the outcomes of SARS-CoV-2-positive kidney transplant recipients in Romania [41]. The prevalence of COVID-19 reached 2.86% in the analyzed SOT population. It confirmed their unfavorable outcomes and high mortality rate. In 43% of infected cases supplemental oxygen was needed, 19% required admission to ICU. Almost all of them have their immunosuppressive treatment lowered. Death rate reached 16.6% (all cases with severe or critical conditions). No episodes of rejection were observed. The analysis revealed no significant differences in terms of kidney function impairment depending on a type of antiviral therapy (antiretrovirals/remdesivir).

The risk of SARS-CoV-2 infection is almost 3 times higher in patients on dialysis when compared to transplanted ones. However, once infection was confirmed, mortality risk was higher in immunosuppressed transplant patients [42]. The Centers for Disease Control and Prevention (CDC) has classified

immunocompromised patients as high-risk for severe COVID-19 disease. Most infected transplant recipients needed to be hospitalized and had radiographic evidence of pneumonia. Many of them required ICU admission or mechanical ventilation. Fatality rates were up to 10 times higher in transplant recipients than in the general population [43,44]. Apart from life-long immunosuppressants predisposing transplant recipients to severe infections, candidates already have a combination of underlying comorbidities. Renal failure patients repeatedly face some risk during hemodialysis sessions. Clarke and colleagues analyzed outcomes of kidney waitlist patients vs first-year transplant recipients and revealed that overall mortality rates after hospital admission was comparable (30% vs 27% in dialyzed vs transplanted, respectively) [45]. Mortality rates of 22%-30% are commonly reported by other authors. Higher mortality was observed in older transplant recipients (over age 60), especially those with cardiovascular disease or dyspnea [46-48]. However, staying long on a waitlist is also associated with increased risk of death. This remains a challenge for both patients and medical staff.

The policy of strict national lockdown was enforced during the first and second wave of the COVID-19 pandemic in European countries. However, some governmental strategies were based only on the recommendations of voluntary self-isolation and social distancing; as a consequence, the Swedish population had to face one of the highest COVID-19 mortality rates in Europe. Therefore, high infection and mortality rates in the Swedish transplant population should be also expected. Felldin et al [49] reported the outcomes of SOT recipients diagnosed with COVID-19 at Sahlgrenska University Hospital, the largest Swedish transplant center. They noted a prevalence of 1.15% among of transplant recipients (compared to 0.74% in total population according to Swedish Public Health Agency reports). Most of them developed mild to moderate (62% of cases in total) illness with the typical symptoms of fever (64%) cough (39.6%), dyspnea (24.5%), gastrointestinal symptoms (30%), or a combination of these. One-third were managed entirely as outpatients. Still, 13% of transplanted SARS-CoV-2-positive patients developed the critical form of COVID-19. They were significantly older, with higher median serum creatinine levels and comorbidity index than those with a less severe disease course. None of the critical patients were within 1 year after transplant. Overall survival was 90.5% (mild or moderate form - 100%, severe form - 90%, critical form - 43%). The mean length of hospital stay was 7 days, ranging from 3 to 33 days. Supportive care and supplemental oxygen were the main interventions; 22% of patients were admitted to an ICU and most of them (19%) required mechanical ventilation. Immunosuppression was reduced in 58% of cases, depending on the disease severity. More than half of those with a mild course had their immunosuppression unchanged. No suspected episodes of rejection were reported.

Most solid organ recipients, if immunocompromised, are at increased risk from coronavirus infection and should be managed adequately to address their higher risk of severe illness from COVID-19. According to data from other coronavirus epidemics (SARS-CoV, MERS-CoV, and SARS-CoV-2), immunosuppressive status alone seems not to be a determinant of a worse prognosis [30]. Increased risk of a more severe course of COVID-19 in immunocompromised adults is related to frequent comorbidities or additional risk factors (eg, age, male sex, diabetes, obesity, hypertension, renal failure or cardiovascular problems) [50]. In general, tailoring immunosuppressive therapy if a transplant recipient acquires COVID-19 is commonly recommended [37,51], but there is no need for pre-emptive reduction of maintenance immunosuppression in asymptomatic patients with an unknown SARS-CoV-2 status. However, in asymptomatic SARS-CoV-2-positive patients with risk factors for a severe course, reducing or stopping azathioprine (AZA)/mycophenolic acid (MPA)/mTOR inhibitors (mTORi) should be considered right away [45]. In recipients with symptomatic COVID-19, reduction of immunosuppression is always recommended, based on severity of the disease and risk of graft rejection. In patients with a mild upper respiratory and/or gastrointestinal symptoms with no symptoms suggestive for COVID-19 pneumonia (eg, dyspnea, intensive cough, or oxygen saturation <95%) and no need for hospitalization. Dual immunosuppressive therapy including steroids is recommended (stopping of AZA/MPA/mTORi if triple therapy was inducted or replacing MPA/mTORi with low-dose steroids if dual). Current immunosuppression may be restarted in 3-7 days after symptoms have cleared. In the mild course of COVID-19 pneumonia, cessation of both AZA/MPA/mTORi and calcineurin inhibitor (CNI) is recommended, with increased doses of steroids until 5-10 days after symptoms have cleared in high-risk patients. Dual CNI-steroid therapy may be continued in those with mild COVID-19 and without risk factors. All immunosuppressive drugs should be discontinued in more severe COVID-19 pneumonia cases (defined as oxygen saturation <94%, respiratory rate >30/min, requiring non-invasive ventilation or ICU admission, including mechanical ventilation). In patients with higher risk of rejection (less than 1 year after transplantation and/or highly immunized), continuing with low-dose CNI may be considered. Restart of previous immunosuppression may occur after 5-15 days without symptoms [52]. A reduction of lymphocyte-depleting therapy during the SARS-CoV-2 pandemic, although not a common practice, is sometimes suggested. Medical Professional Societies do not comment or recommend against prophylactic anti-SARS-CoV-2 therapy. Remdesivir is allowed for use by the American Association for the Study of Liver Diseases (AASLD), whereas the National Health Service in the UK recommends potential use of therapeutic antivirals within a clinical trial. Lopinavir-ritonavir is not recommended by the United Network for Organ Sharing (UNOS) or AASLD in transplant recipients due to drug-drug interaction considerations [13].

## COVID-19 and Transplantation in Asia

South Korea was one of the first countries worldwide facing the COVID-19 outbreak and quickly became the one with the highest number of infected cases after China. Because of the lessons learned from the previous MERS (Middle-East Respiratory Syndrome) outbreak, all national-level efforts were concentrated to limit the spread of a new coronavirus pandemic. In accordance with the Korean Transplantation Society recommendation, most transplant centers adopted universal donor and recipient screening using RT-PCR tests. National kidney transplant activities, for both living and deceased donor transplants, remained stable when compared to the previous year [53]. Liver transplantation procedures were constantly in progress at most transplant centers, except for hospitals with high COVID-19 occurrence [54].

Guidelines have been framed by the COVID-19 Working Group of the Indian Society of Nephrology and the Indian Society of Organ Transplantation for restarting transplant activity in India after its temporary slowdown in the course of the first wave of the pandemic [55]. They are quite similar to the recommendations approved in most other countries. Potential donors with epidemiological risk (defined as exposure to a confirmed COVID-19 case or international travel in the last 14 days) and a clinical picture corresponding to COVID-19 are not processed further even when screening results are negative. Positivity for clinical criteria (unexplained respiratory failure, acute respiratory infection, severe bilateral pneumonia) or SARS-CoV-2 test are obvious contraindications. Routine testing should be undertaken in all potential organ donors within 72 hours prior to donation. All transplant recipients, being at higher risk of severe COVID-19 course in case of SARS-CoV-2 infection, should strictly follow the governmental restrictions and recommendations and take extra precautions. Fourteen days of quarantine and isolation is applied to those exposed to confirmed or suspected COVID-19 cases, similar to the general population.

## COVID-19 and Transplantation in North America

Chorankeril et al retrospectively analyzed month-to-month trends on waitlist deaths and additions, and transplant procedures in UNOS [56]. They found that the number of transplant operations fell by 25-50% in most USA states. Compared with the first months of 2020, just before the outbreak of the pandemic, monthly average numbers of transplants in April 2020 decreased by 35.9%. The largest fall was observed in kidney and lung transplants (kidney – 42.9%; lung – 40.4%; heart – 26.0%; liver – 20.7%). New additions to the waitlist decreased by 23.3% (lung – 34.3%; heart – 34.2%; kidney – 25.1%; liver – 10.2%). The total number of deaths on the waitlists rapidly

increased by 26.2%. The largest growth of death rates has been reported in the kidney waitlist (kidney – 43.0%; lung – 11.8%; liver – 7.7%). A multicenter retrospective cohort study conducted by Hsu et al [57] on risk factors of and outcomes from COVID-19 among maintenance dialysis patients demonstrated a 5.5% rate of infection, inter alia, due to inability of effective physical distancing as a consequence of regular in-center hemodialysis and associated transportation, as well as frequent need of social support and caregivers in daily activities. About 60% of SARS-CoV-2-positive dialysis patients required hospitalization, and the mortality risk among this group approached 25%. By comparison, the mortality rate among the non-COVID dialysis patients was 4% [58]. With an obvious priority of living donor safety, most transplant centers decided to suspend living donor transplantation procedures. Volumes of living donor kidney transplantation (LDKT) activity during the pandemic decreased by at least 50% compared to pre-pandemic levels. LDKT programs were paused by 66% of transplant centers (49% in “low” and 81% in “high” COVID-19 cumulative incidence states). Evaluation of new donor candidates had been halted or very much decreased (to less than 25% of its normal activity) [59]. The National Kidney Registry reported an 89% drop in LDKT in April 2020, related to concerns about donor safety and unknowns that appeared at the beginning of the pandemic with a new pathogen. It returned to more than 60% of pre-COVID-19 rates a few months later, in June 2020 [60].

A limited access to organ procurement also affects other transplant programs. Significant decreases in deceased donor liver transplants and increased mortality on LT waitlists were noted in states with the highest COVID-19 burden early on. The number of new listings was less in the initial months of the pandemic, but returned to expected values during the summer months of 2020. Total numbers of living donor LTs observed were more than 40% lower than expected from March to May. However, in the June–August period it was as expected. To the end of April 2020, deceased donor LTs decreased by 10% to grow higher than expected by 15% in the following months. Overall, the number of waitlist deaths was not significantly different from expected [61].

International survey in 78 responders from the USA and Western Europe investigated the impact of the COVID-19 pandemic on lung transplant programs. Over 80% declared a decrease of their activity as compared with pre-pandemic era. More than half (47%) of participating centers restricted lung transplantation to urgent cases only, 20% observed deaths on the waitlists, and 62% faced SARS-CoV-2 infection in lung transplant recipients. Eight per cent of responders performed rescue lung transplantation in a patient with COVID-19 acute respiratory distress syndrome (ARDS) [62].

Heart transplant (HT) volumes have been significantly reduced during the pandemic in the USA as compared to the pre-COVID-19 era. Even regions with a low number of COVID-19 cases were affected. DeFilippis and colleagues [63] retrospectively analyzed UNOS data on adult HT candidates. They revealed a 37% reduction in waitlist additions and a 75% increase in waitlist suspensions during the initial period of the pandemic, mostly observed in regions with high COVID-19 morbidity.

The risk of donor-derived SARS-CoV-2 infection notwithstanding, an issue of nosocomial SARS-CoV-2 infection of transplant candidate, as well as living donor during the transplant hospitalization, remains unresolved. Apart from screening and strict isolation of patients, separation from outpatients and intensive care beds for transplantation seem reasonable. Insufficient evidence and long-term follow-up drive a dispute about whether transplant therapy should be continued without limitations or should be restricted to urgent cases. It seems that decisions need to be made case-by-case, according to individual risk assessment and local epidemic situation [64].

For some COVID-19 respiratory failure patients with ARDS or end-stage pulmonary fibrosis, lung transplant programs became life-saving. Although most centers analyzed by Coiffard [62] restricted lung transplantation to urgent cases, and the number of lung transplants decreased in 2020, and some transplant units reported having performed lung transplantation as a rescue therapy for patients with COVID-19.

## Conclusions

This review has shown that the effects of the COVID-19 pandemic on solid organ transplantation during 2020 in Poland were comparable to those in countries in Western Europe, Asia, and North America. The ability to monitor organ donors and recipients and monitor their SARS-CoV-2 status has relied on national registries, such as POLTRANSPLANT. It is clear that SARS-CoV-2 infection will continue to place an increasing demand on national and international transplant services and will require accurate infection screening. National and international guidelines will likely continue to develop as the long-term effects of SARS-CoV-2 infection are increasingly recognized.

## Conflict of Interests

None.

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