Informing the Risk of Kidney Transplantation Versus Remaining on the Waitlist in the Coronavirus Disease 2019 Era

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Introduction: There are limited data pertaining to comparative outcomes of remaining on dialysis versus kidney transplantation as the threat of coronavirus disease 2019 (COVID-19) remains. In this study we delineate the differential risks involved using serologic methods to help define exposure rates.

Methods: From a cohort of 1433 patients with end-stage kidney disease (ESKD), we analyzed COVID-19 infection rates and outcomes in 299 waitlist patients compared with 237 transplant recipients within their first year post-transplant. Patients were followed over a 68-day period from the time our transplant program closed due to COVID-19.

Results: The overall mortality rates in waitlist and transplant populations were equivalent ($P = 0.69$). However, COVID-19 infection was more commonly diagnosed in the waitlist patients ($P = 0.001$), who were more likely to be tested by reverse transcriptase polymerase chain reaction ($P = 0.0004$). Once infection was confirmed, mortality risk was higher in the transplant patients ($P = 0.015$). The seroprevalence in dialysis and transplant patients with undetected infection was 18.3% and 4.6%, respectively ($P = 0.0001$). After adjusting for potential screening bias, the relative risk of death after a diagnosis of COVID-19 remained higher in transplant recipients (hazard ratio = 3.36 [95% confidence interval = 1.19–9.50], $P = 0.022$).

Conclusions: Although COVID-19 infection was more common in the waitlist patients, a higher COVID-19–associated mortality rate was seen in the transplant recipients, resulting in comparable overall mortality rates.

The COVID-19 pandemic has had a dramatic impact on transplantation globally, with donation rates plummeting and many transplant centers having to temporarily close.[1,2] As transplant activity starts to recover, the planning involved in restarting programs amidst the ongoing threat of COVID-19 is not purely a logistical one. Although it has long been recognized that kidney transplantation offers a better prognosis over remaining on dialysis, there are limited data pertaining to comparative outcomes during the COVID-19 pandemic.[3–5] It is unknown whether there are any additional risks of acute transplantation in terms of either acquiring COVID-19 infection, such as by nosocomial transmission, or by affecting the outcomes of infection, such as by influence of immunosuppression. Clearly, there have been many reports of a poor prognosis in COVID-19–infected maintenance transplant recipients.[6–9]

What has also been identified are the unmodifiable risk factors associated with a poor prognosis, namely

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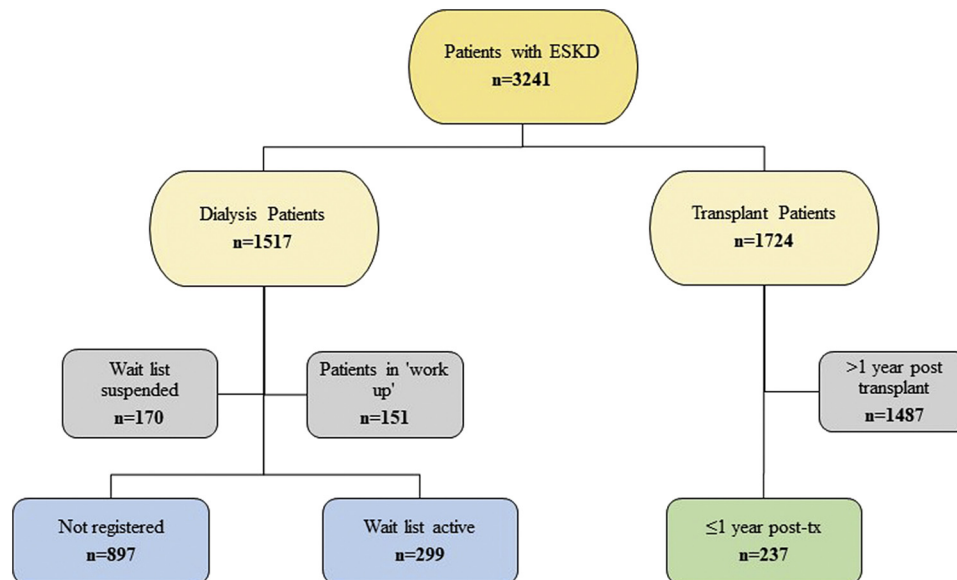[4]These authors contributed equally to this work.

Figure 1. Study flow diagram. ESKD, end-stage kidney disease.

advanced age, ethnicity, and comorbidities, including hypertension, diabetes, and chronic kidney disease.[10,11] We also know that infection rates in the dialysis population, especially in patients receiving in-center hemodialysis (ICHD), have been high, and that this has been associated with overwhelming mortality rates.[12–14] In the absence of transferring to home dialysis therapy, transplantation is the only other alternative option to limit hospital exposure for these patients. Therefore, data to help inform the relative risk of transplantation are required.

We undertook an analysis with an aim to help delineate the risk of remaining on the waitlist compared with acute transplantation in the COVID era.

METHODS

Patient Selection
As shown in Figure 1, we reviewed 3241 patients with ESKD at Imperial College Renal and Transplant Centre, London. Waitlist patients were those registered as active at the time the transplant program closed on 18 March 2020. We excluded patients who were registered, as "in work-up," "suspended," "predialysis," or were receiving dialysis external to Imperial College Healthcare National Health Service Trust. Home dialysis therapy included both home hemodialysis and peritoneal dialysis. The transplant cohort included all patients with a functioning allograft who had received a transplant at least 1 year before 18 March 2020. Patients' demographics and clinical outcome measures were obtained from the departmental renal and transplant registries. All patients were followed-up for 68 days, during which the transplant program remained closed.

Diagnosis and Screening for Severe Acute Respiratory Syndrome Coronavirus 2 Infection
All clinical cases of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection were confirmed by the detection of viral RNA by reverse transcriptase polymerase chain reaction (RT-PCR). Cases were identified either after symptomatic presentation as an inpatient or by routine screening in the outpatient setting.

From March 17, 2020, all dialysis patients underwent nasopharyngeal swabbing if they were found to have developed either a temperature or COVID-19–related symptoms when attending outpatient dialysis treatment. Using a similar protocol, all transplant patients were screened when they attended the transplant outpatient phlebotomy service.

SARS-CoV-2 Antibody Detection
Transplant recipients and dialysis patients without a confirmed diagnosis of COVID-19 by RT-PCR were tested for the presence of SARS-CoV-2 immunoglobulin G, using the Abbott assay. Samples were interpreted as positive or negative according to the manufacturer's instructions with a cutoff index value of 1.4. Transplant patients were sampled between June 1 and July 3, 2020.

Immunosuppression Treatment Protocols
The immunosuppression protocol at our institution consists of monoclonal antibody induction for all patients with either alemtuzumab (Campath 1H, Genzyme) or basiliximab (Simulect, Novartis). Patients routinely receive alemtuzumab unless have had a history of malignancy, have active hepatitis B or C, are part of a clinical trial, or have received significant

Table 1. Comparison of patient characteristics in those with ESKD on dialysis according to waitlist status

Variable	Waitlist active, N = 299[a]	Not registered, N = 897[a]	P value
Gender			0.26
Male	182 (60.9)	513 (57.2)	
Female	117 (39.1)	384 (42.8)	
Median age, yr (IQR)	55 (44–64)	74 (64–80)	<0.0001[b]
Ethnicity			
White	76 (25.4)	317 (35.3)	0.002[b]
BAME	223 (74.6)	580 (64.7)	
Cause ESKD			0.002[b] (diabetes as comparator)
APKD	18 (6.0)	32 (3.6)	
Diabetes	84 (28.1)	341 (38.0)	
GN	80 (26.8)	152 (16.9)	
Other	34 (11.4)	113 (12.6)	
Unknown	67 (22.4)	214 (23.9)	
Urologic	16 (5.4)	45 (5.0)	
Place of dialysis			<0.0001[b]
Home	54 (18.1)	84 (9.4)	
Hospital	245 (81.9)	813 (90.6)	
Median time in ESKD, mo (IQR)	20 (9–36)	22 (20–24)	0.25

APKD, autosomal dominant polycystic kidney disease; BAME, Black, Asian, and Minority Ethnic; ESKD, end-stage kidney disease; GN, glomerulonephritis; IQR, interquartile range.
[a]Data are n (%), unless otherwise noted.
[b]Statistically significant.

cumulative immunosuppression pretransplant. Maintenance immunosuppression consists of tacrolimus with a steroid minimization protocol, with 1 week of corticosteroids only, unless on long-term steroids pretransplant. In addition, mycophenolate mofetil (MMF) was prescribed for patients who received an interleukin-2 receptor antagonist or a simultaneous pancreas and kidney transplant. In response to the new deceased donor organ allocation scheme in the United Kingdom, which started in September 2019, all HLA-sensitized patients with a calculated reaction frequency of ≥85% also received MMF. Rejection episodes were biopsy proven and treated as described elsewhere.[15]

Transplant recipients were who diagnosed with COVID-19 infection and managed as outpatients, had MMF withdrawn, and were prescribed antibiotics to prevent secondary infection. Outpatient dialysis patients received no viral-specific therapy. All inpatients, regardless of renal replacement modality, were treated at the discretion of the responsible physician and according to trial protocols if relevant.

Statistical Analysis
Normally distributed variables were compared using Student's t test and nonparametric data were compared using the Mann-Whitney U test. The χ^2 test was used for proportional assessments. Using the log rank test, Kaplan-

Meier analyses were used to estimate and compare patient survival after SARS-CoV-2 infection. Cox proportional hazards regression analyses were used to identify the hazards of infection and patient survival. Patient survival was censored for nonconfirmed COVID-19–related death. Data are reported as mean ± standard deviation or median and interquartile range as appropriate. Statistical analyses were performed using MedCalc version 1.9. The 2-sided level of significance was set at $P < 0.05$.

RESULTS

COVID-19 Infection and Mortality in Waitlist Versus Non-waitlist Patients
Given the high mortality rates reported in dialysis patients, we first investigated the distinct impact of COVID-19 infection in waitlist versus nonregistered dialysis patients.

Patients' Characteristics
As shown in Figure 1, 1366 patients were receiving dialysis, of whom 299 (21.9%) were active on the waitlist with 897 (65.7%) unregistered at the time of transplant service closure. Table 1 shows the baseline characteristics of the waitlist and nonregistered patients. The waitlist patients were younger ($P < 0.001$), more likely to be White ($P < 0.0001$), more likely to be undertaking dialysis therapy at home ($P < 0.0001$), and less likely to have ESKD secondary to diabetes ($P = 0.0002$) compared with the nonregistered patients.

Symptomatic Infection Rates and Mortality
There was no difference in the incidence of RT-PCR–confirmed COVID-19 cases in the waitlist patients compared with the nonregistered patients, with 53 of 299 (17.7%) and 202 of 897 (22.5%) cases, respectively ($P = 0.059$, by log–rank test), as shown in Figure 2a. Overall, all-cause patient survival was higher in the waitlist patients compared with the nonregistered patients ($P < 0.0001$). After censoring for death in patients with nonconfirmed diagnoses of COVID-19 infection, patient survival remained superior in the waitlist patients ($P = 0.0001$), as shown in Figure 2b. Six of 53 (11.3%) waitlist patients with confirmed COVID-19 died compared with 75 of 202 (37.1%) of nonregistered patients. One patient on the waitlist died without confirmed COVID-19 infection during the follow-up period compared with 17 nonregistered patients.

COVID-19 Infection and Mortality in Waitlist Patients Versus Patients Within Their First Year Post-transplant
Of the 237 transplant patients within the first-year post-transplant at our center, 16 (6.8%) had COVID-19 infection confirmed by RT-PCR.
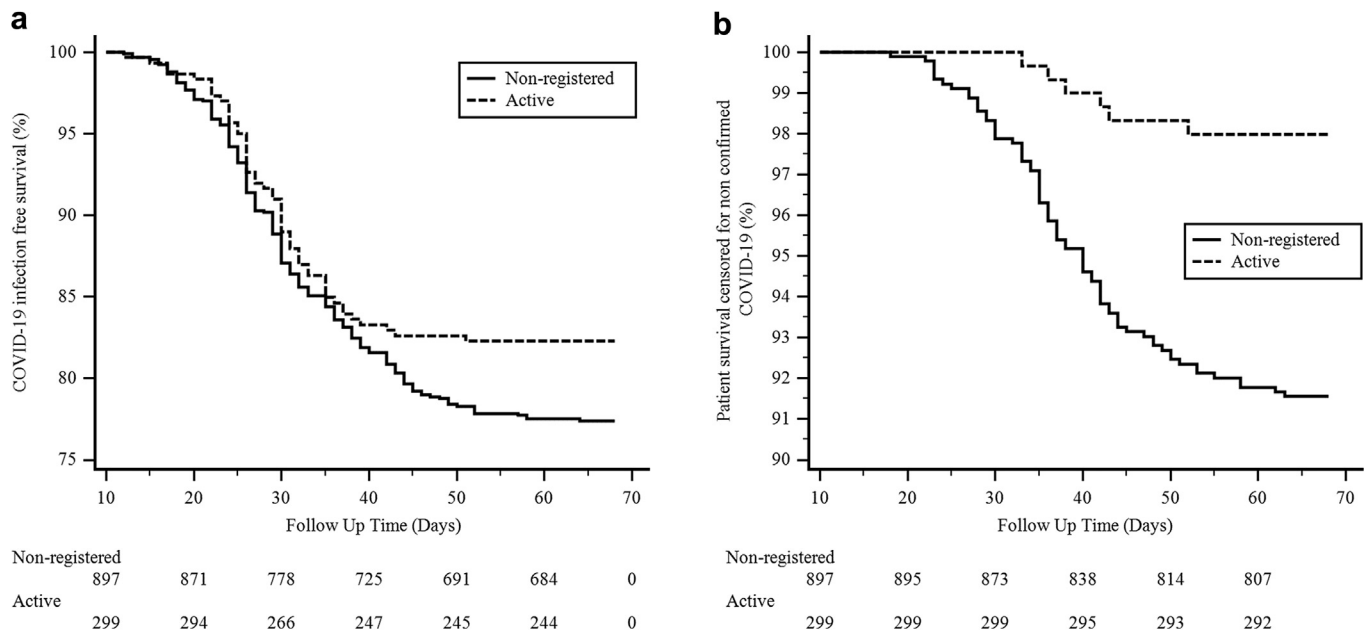
Figure 2. Comparison of infection rates and outcome by waitlist status. (a) Coronavirus disease 2019 (COVID-19)–infection–free survival by waitlist status. There was no significant difference in COVID-19–free survival in nonregistered patients compared with patients active on the waitlist ($P = 0.059$). (b) COVID-19-infection–free survival by waitlist status. There was no significant difference in COVID-19–free survival in nonregistered patients compared with patients active on the waitlist ($P = 0.059$). (c) Patient survival by waitlist status in those with COVID-19 infection. Patient survival censored for nonconfirmed COVID-19 infection was significantly lower in nonregistered patients compared with waitlist patients ($P = 0.0001$).

Patients' Characteristics

Table 2 presents a comparison of transplant patients with and without confirmed COVID-19 infection. Patients with COVID-19 were more likely to be within the first 3 months post-transplant; 10 of 16 (62.5%) COVID-19–positive patients were still in their early follow-up period, compared with 79 of 221 (35.7%) of the negative patients ($P = 0.015$). There was a higher proportion of patients from Black, Asian, and Minority Ethnic backgrounds in the COVID-19–positive group, with 15 of 16 (93.7%) and 151 of 221 (68.3%) Black, Asian, and Minority Ethnic patients in the infected and noninfected groups, respectively ($P = 0.032$). Transplant patients with COVID-19 had spent a longer time on dialysis pretransplant, with a median dialysis vintage of 4.6 (3.4–5.3) years, compared with 2.8 (2.3–3.4) years in the COVID-19–negative patients ($P = 0.015$). There was also a higher proportion of patients with a diagnosis of diabetes in the COVID-19–positive group. Twelve of 16 (75.0%) had diabetes in the COVID-19–positive group and 89 of 221 (40.3%) patients in the COVID-19–negative group ($P = 0.007$).

Symptomatic Infection Rates and Mortality

There was no difference in overall patient survival between transplant and waitlist patients during the follow-up period ($P = 0.69$), as shown in Figure 3a. However, as shown in Figure 3b, significantly more patients on the waitlist had a confirmed diagnosis of

COVID-19 compared with the transplant patients ($P = 0.001$). Therefore, patient survival was significantly worse in transplant patients once diagnosed with COVID-19 compared with waitlist patients ($P = 0.015$), as shown in Figure 3c. Six of the 16 (37.5%) transplant patients who were diagnosed with COVID-19 died, compared with 6 of 53 (11.3%) waitlist patients. Three of the 6 transplant patients who died were within 3 months of their transplant. There were no differences in the other baseline demographics between the patient groups (Supplementary Table S1).

Impact of Immunosuppression on Outcomes in Waitlist Patients

Given the significant difference in mortality between the transplant and waitlist groups, we next explored the impact of immunosuppression within the waitlist patient group. Fifty-one of 299 (17.1%) waitlist patients were receiving immunotherapy, of whom 8 (15.7%) were diagnosed with COVID-19 compared with 45 of 248 (18.1%) of the non-immunosuppressed patients ($P = 0.68$), as shown in Figure 4a. Ten (19.6%) patients were receiving immunosuppression for an underlying autoimmune disease, whereas 41 of 51 (80.4%) patients were receiving immunosuppression after returning to dialysis after transplant failure (Supplementary Table S2). There was no difference in patient survival after diagnosis with COVID-19

Table 2. Baseline transplant characteristics by COVID-19 status

Variable	COVID-19$^+$, n = 16	COVID-19$^-$, n = 221	P value
Gender			0.60
Male	9 (56.2)	139 (62.9)	
Female	7 (43.7)	82 (37.1)	
Age, median (IQR)	56 (47–65)	57 (54–58)	0.78
Ethnicity			0.032
White	1 (6.2)	70 (31.7)	
BAME	15 (93.7)	151 (68.3)	
Cause of ESKD			0.008 (DM as comparator)
APKD	0	15 (6.8)	
DM	10 (62.5)	67 (30.3)	
GN	1 (6.2)	58 (26.2)	
Other	0	13 (5.9)	
Unknown	5 (31.2)	56 (25.3)	
Urologic	0	12 (5.4)	
Graft number			0.19
First transplant	4 (25.0)	192 (86.9)	
Second or later transplant	12 (75.0)	29 (13.1)	
Graft type			0.11 (living donor comparator)
Deceased donor	15 (93.7)	159 (71.9)	
DBD	10 (66.7)	94 (59.1)	
DCD	5 (33.3)	65 (40.9)	
Living donor	1 (6.2)	54 (24.4)	
SPK	0	8 (3.6)	
Pre-emptive			0.69
Yes	2 (12.5)	36 (16.3)	
No	14 (87.5)	185 (83.7)	
Time at ESKD, yr (median)	4.6 (3.4–5.3)	2.8 (2.3–3.4)	0.015
HLA-sensitized			0.39
Yes	9 (56.2)	100 (45.2)	
No	7 (43.7)	121 (54.8)	
Time post-transplant			0.03
<3 mo	10 (62.5)	79 (35.7)	
>3 mo	6 (37.5)	142 (64.3)	
Induction			0.70
Alemtuzumab	14 (87.5)	200 (90.5)	
IL-2RA	2 (12.5)	21 (9.5)	
Rejection			0.34
Yes	2 (12.5)	14 (6.3)	
No	14 (87.5)	207 (93.7)	
Diabetes			0.007
Yes	12 (75.0)	89 (40.3)	
No	4 (25.0)	132 (59.7)	
IHD			0.28
Yes	5 (31.2)	44 (19.9)	
No	11 (68.7)	177 (80.1)	
Hypertension			0.66
Yes	11 (68.7)	153 (73.8)	
No	5 (31.2)	58 (26.2)	

APKD, autosomal dominant polycystic kidney disease; COVID-19, coronavirus disease 2019; DBD, donation after brain death; DCD, donation after cardiac death; DM, diabetes mellitus; ESKD, end-stage kidney disease; HLA, human leukocyte antigen; GN, glomerulonephritis; IHD, ischemic heart disease; IL-2RA, interleukin-2 receptor antagonist; IQR, interquartile range; SPK, simultaneous pancreas and kidney.

between those patients who were immunosuppressed versus those not immunosuppressed ($P = 0.20$), as shown in Figure 4b.

Investigating the impact of previous transplantation within this cohort, 74 of 299 (24.7%) waitlist patients had received a transplant historically, of whom 33 (44.6%) had immunotherapy withdrawn. Twelve of 74 (16.2%) patients with failed transplants were diagnosed with COVID-19 compared with 41 of 225 (18.2%) waitlist patients who were waiting for their first transplant ($P = 0.70$). There was no difference in patient survival after a diagnosis of COVID-19 between those who had previously received a transplant and those who had not ($P = 0.48$).

Multivariable Analysis of Risk Factors for Symptomatic COVID-19 Infection and Mortality in Waitlist and Transplant Patients

Risk of RT-PCR–confirmed symptomatic COVID-19 infection for patients on dialysis was assessed by multivariate analysis, including variables that had been shown to be significantly associated with infection on univariate analysis, namely age, ethnicity, gender, waitlist status, reaching ESKD secondary to diabetes, and receiving home therapy. A diagnosis of ESKD due to diabetes was found to be an independent risk factor for symptomatic infection (hazard ratio [HR] $= 1.47$ [95% confidence interval {CI} $= 1.16–1.87$], $P = 0.0013$), whereas receiving home dialysis therapy was protective (HR $= 0.27$ [CI $= 0.14–0.51$], $P = 0.0001$).

Older age (HR $= 10.3$ [CI $= 1.01–1.05$], $P = 0.0054$) and ESKD secondary to diabetes (HR $= 1.82$ [CI $= 1.18–2.80$], $P = 0.0065$) were associated with increased mortality risk after a diagnosis of COVID-19 in dialysis patients. However, dialysis patients who were registered on the transplant waitlist had a better overall prognosis (HR $= 0.32$ [CI $= 0.15–0.71$], $P = 0.005$).

On multivariable analysis of risk factors associated with a diagnosis of RT-PCR–confirmed symptomatic COVID-19 in renal transplant recipients, only a diagnosis of diabetes (HR $= 4.25$ [CI $= 1.17–15.48$], $P = 0.0278$) remained as a predictor of infection in patients within the first year post-transplant. Multivariable analysis of factors associated with death in transplant patients was not possible.

Serologic Analysis to Investigate Potential Diagnostic Bias in Waitlist Versus Transplant Patients

Figure 5 summarizes the prevalence and outcome of COVID-19 infection in transplant recipients and waitlist and nonregistered patients. Given the higher mortality seen in transplant recipients with confirmed infection compared with waitlist patients, we undertook a serologic study of SARS-CoV-2 antibodies to address a potential screening bias. Of the 221 transplant patients who were not diagnosed with COVID-19,
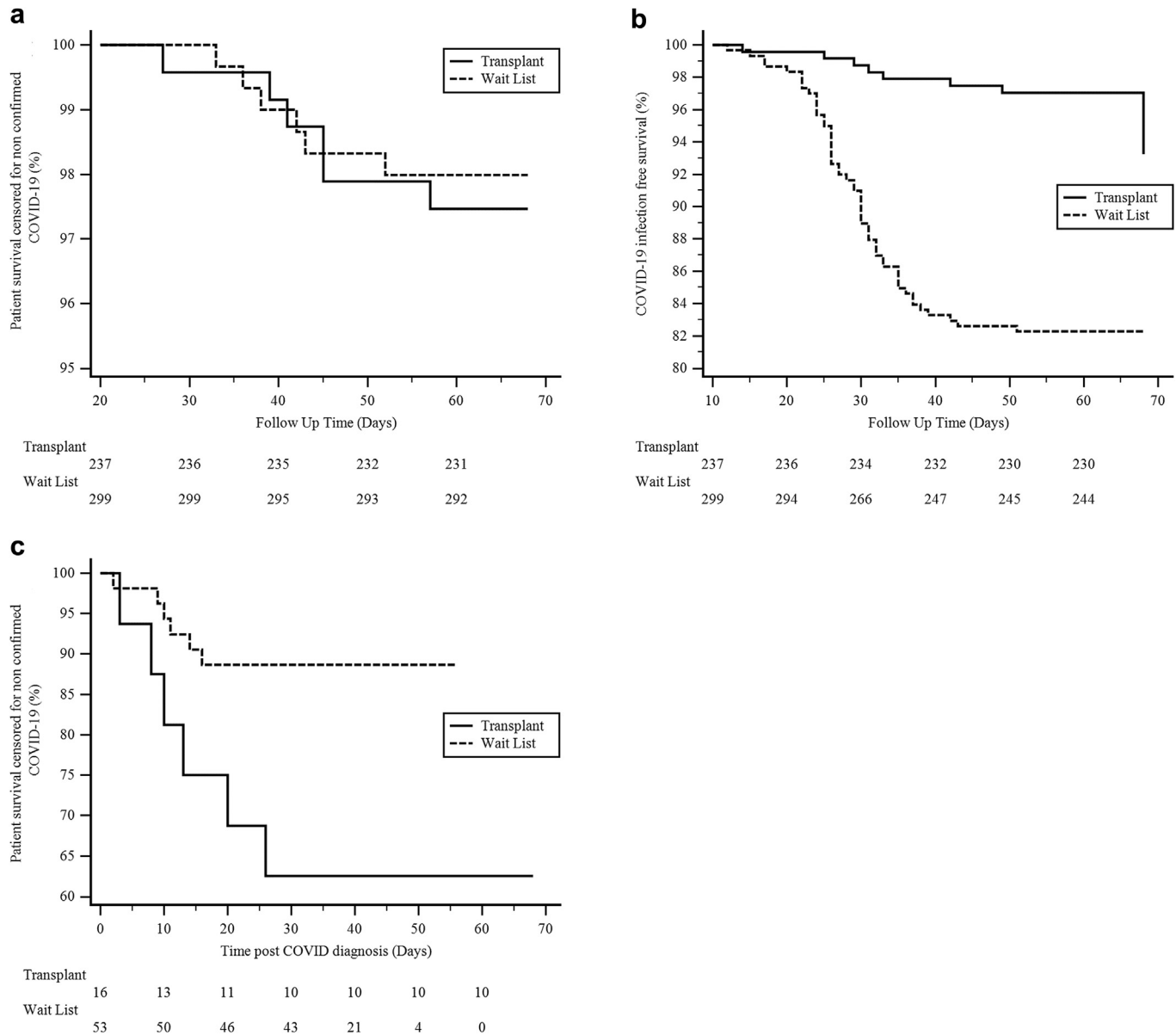
Figure 3. Comparison of infection rates and outcome by transplant and active waitlist status. (a) Overall patient survival. There was no difference in overall patient survival between the waitlist patients and transplant patients during the follow-up period ($P = 0.69$). (b) Coronavirus disease 2019 (COVID-19)–infection–free survival in transplant and waitlist patients. Waitlist patients were more likely to be diagnosed with COVID-19 than transplant patients ($P = 0.001$). (c) Patient survival after COVID-19 infection in transplant and waitlist patients. After a diagnosis of COVID-19, transplant patients had an inferior survival compared with waitlist patients ($P = 0.015$).

196 (88.7%) were tested for SARS-CoV-2 antibodies. Nine of 196 (4.6%) additional transplant recipients had serologic evidence of exposure to COVID-19. This was significantly less than the 31 of 169 (18.3%) randomly selected waitlist patients with undetected infection who were serologically screened ($P = 0.0001$). A comparison of the patient characteristics associated with a RT-PCR and serologic diagnosis in the waitlist and transplant patients may be found in Supplementary Tables S3 and S4. Although the addition of serologic testing reduced the mortality rates associated with confirmed infection to 6 of 25 (24.0%) in transplant recipients and 6 of 84 (7.1%) in waitlist

patients, the relative risk of death after a diagnosis of COVID-19 remained higher in transplant recipients (HR = 3.36 [CI = 1.19–9.50], $P = 0.022$).

DISCUSSION

This study has demonstrated several major observations that highlight some of the considerations required for the individual risk stratification of potential renal transplant recipients during the COVID-19 outbreak. In brief, we have shown that dialysis patients are a heterogeneous population, and comparisons of COVID-19 infection must reflect the divergent outcomes
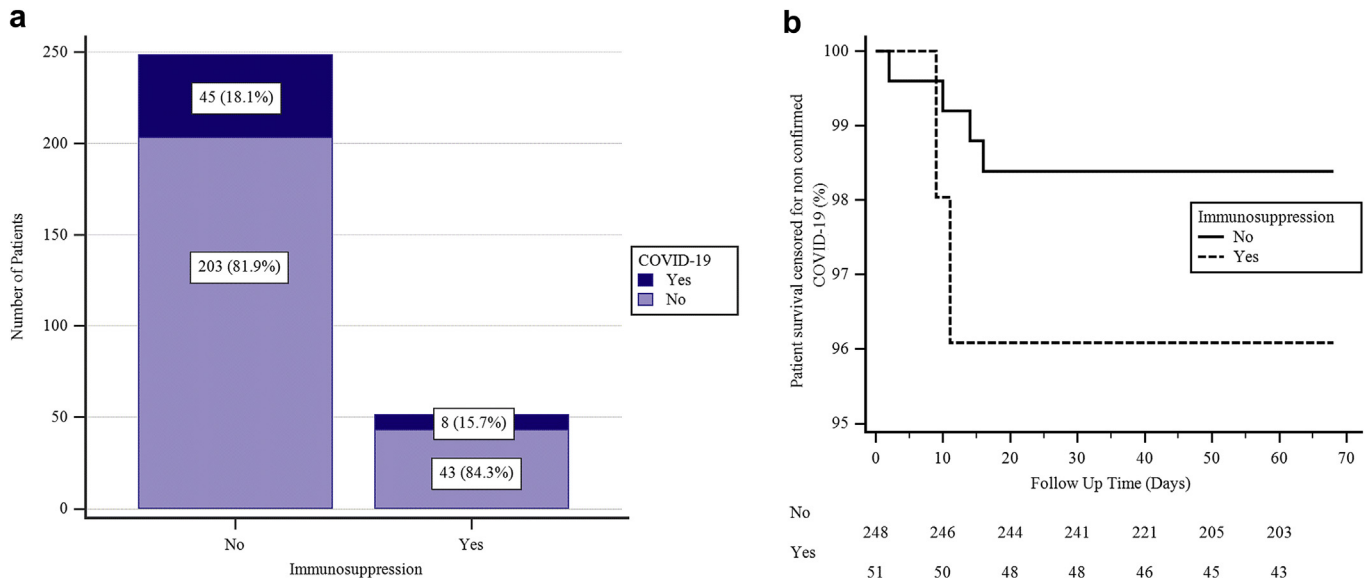
Figure 4. Number of patients active on the waitlist on immunosuppression and impact on Coronavirus disease 2019 (COVID-19) diagnosis and outcome. (a) Correlation between immunosuppression use and COVID-19 diagnosis. There was no difference in the proportion of waitlist patients diagnosed with COVID-19 in those receiving immunosuppression ($P = 0.68$). (b) Patient survival after COVID-19 on the waitlist by immunosuppression use. There was no difference in patient survival after a diagnosis of COVID-19 in those patients receiving immunosuppression compared with those who were not ($P = 0.20$).

between waitlist and nonregistered dialysis patients. Although we have shown that the overall mortality rates in waitlist and transplant patients were equivalent on a population level, confirmed infection rates were significantly higher in the waitlist patients. Given the potential bias posed by the routine screening performed in dialysis patients, we used serologic methods to investigate more accurately the prevalence of COVID-19 infection rates in transplant patients. Serologic surveillance confirmed higher exposure rates than had been clinically detected, but this was applicable to

both the transplant and dialysis populations, leading to the conclusion that, once infected, mortality rates were higher in transplant recipients compared with waitlist dialysis patients.

The finding that the outcome of COVID-19 infection in ESKD patients differs between waitlist and non-registered patients is unsurprising. We have assumed this reflects that non-waitlist patients are a more vulnerable or frail group. In typical circumstances, it is well recognized that nonregistered patients have worse survival than waitlist patients.[3] Demonstration of the
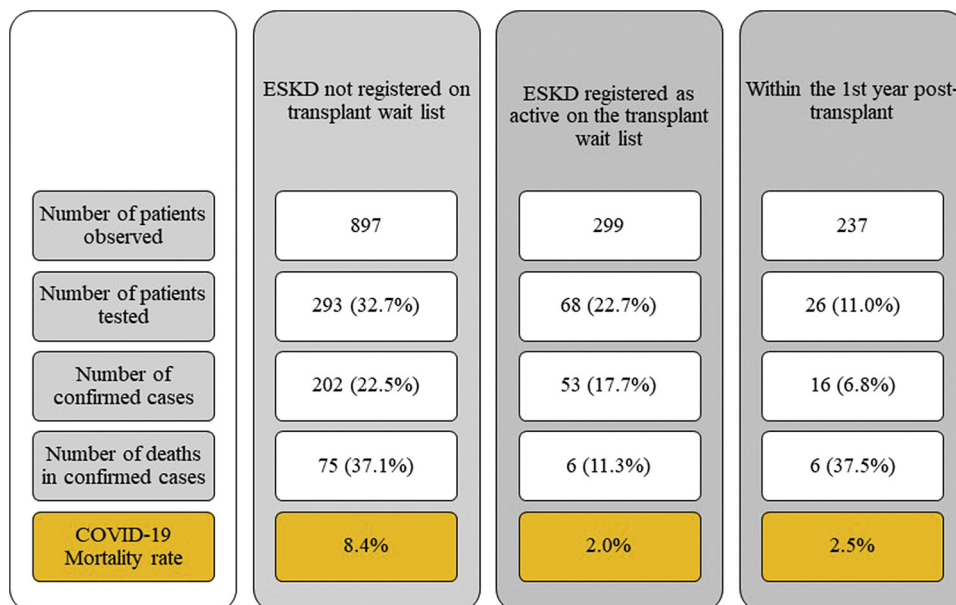

Figure 5. Summary of rates of infection and mortality between transplant, waitlist, and nonregistered patients. ESKD, end-stage kidney disease.

different outcomes from COVID-19 is important, because, although all patients with ESKD were asked to shield by the UK government due to their "vulnerable" status, it is likely that outcome, if infected, could be determined by age and comorbidity burden.[16] Given that outcomes with COVID-19 infection for dialysis patients, especially in-center hemodialysis outcomes, have been alarming, a breakdown of reports by waitlist status and age may help inform transplant teams considering restarting transplantation programs.[12,13]

We found patients undertaking dialysis at home had an extremely low risk of infection. We assume this is due to the ability to effectively shield, as reported elsewhere.[17] Therefore, it may be argued that stable patients on established home dialysis therapy may be urged to avoid transplantation until further evidence emerges on acute transplant outcomes. Conversely, this may just reflect the screening bias of ICHD patients, which would portend to only moderate to severe infections being detected in home dialysis patients. Data from the UK renal registry support this hypothesis.[13] As of July 1, 2020, there were only 120 confirmed cases of COVID-19 in home dialysis patients; however, the death rate was 49 of 120 (40.8%), significantly higher than the 593 of 2292 (25.9%) rate seen in patients receiving ICHD ($P < 0.01$).

Before this study, we considered that the same diagnostic bias may be applied to transplant recipients, with data from National Health Service Blood and Transplant showing that only 546 of 39,097 (1.4%) of all prevalent kidney transplant patients in the UK had COVID-19 infection confirmed as of June 19, 2020.[2] Despite this low prevalence, an epidemiologic analysis of factors contributing to in-hospital COVID-19 deaths in the UK has shown that solid-organ transplantation is an independent risk factor for death.[11] From the 20,130 solid-organ transplant recipients included in the study, transplant patients had an adjusted HR of 4.27 (3.20–5.70) of death.[11] Given that established transplant patients are more likely to be able to "shield" than *de novo* transplant patients, a more detailed subanalysis of this transplant population is urgently needed to identify risk in acute transplantation. It is likely that, similar to the dialysis population, the UK transplant population represents a diverse group of patients with differing prognoses. For acute transplantation, it should also be highlighted that risk of infection acquisition is likely to change during subsequent surges of infection, given the heightened awareness and simple physical preventive measures that have been implemented globally.

One unavoidable potential risk of undertaking transplantation involves the use of immunosuppression.[16] Therefore, we investigated the incidence and outcome of COVID-19 infection in dialysis patients who were receiving immunotherapy, either indicated for a retained failed renal transplant or an underlying autoimmune disease. One could hypothesize that these patients would be at risk of infection and a subsequent poor outcome. We found that 17.1% of our waitlist patients were receiving immunosuppression but saw no increased risk of being diagnosed with infection or death in this patient group, although the numbers are too small for conclusive interpretation. Corroboration of this observation will be clinically informative, although any analysis should consider that immuno-therapeutic agents may have differential effects on COVID-19 outcomes.[18,19] It is also important to highlight that the risk of immunosuppression in this subgroup of dialysis patients is not comparable to that in patients within their first year post-transplant, when the risk of any infection is at its highest.[20] In terms of optimal transplant induction regimens, both from the safety and efficacy perspective, national data sets will most likely enable the provision of evidence; however, although the threat of further waves of COVID-19 remain, bespoke immunosuppression trials may be required.

When stratifying individual risk of transplantation, consideration may also be needed for type of donor. Although deceased donor transplants rely on an operational national infrastructure and are unpredictable for recipient "shielding," direct living donor transplantation only requires local and elective pathways, which may be easier to predict and manage. It is also noteworthy that only 1 of the 16 transplant recipients with symptomatic COVID-19 in our cohort had received a living donor transplant. Complications, such as delayed graft function and suboptimal function, are less common after living donor transplantation, which may help minimize health-care exposure and risk of infection in recipients. Therefore, from a recipient perspective, living donor transplantation should remain the preferential choice when available.

This study has several limitations. We have assumed that nonregistered patients were not waitlisted because of comorbidity and frailty, although this may be due to other reasons (e.g., patient choice). We have not included predialysis patients in this study, which requires further study. We used patients within 1 year of transplant as a surrogate for *de novo* transplant patients, who may not necessarily share a similar risk profile. We used antibody detection to aid infection prevalence in transplant recipients, although serologic testing in immunocompromised populations has not been validated. The study does, however, provide detailed data on a large patient cohort in terms of risk of infection and prognosis of waitlisted compared with transplant patients, in a high COVID-19–prevalent region. Despite

limited data on the ability of transplant recipients to seroconvert, our study identified a significant number of asymptomatic transplant patients who had evidence of exposure, resulting in a 10.5% prevalence of either RT-PCR or serologically confirmed infection. Although substantially less than infection rates in patients on the waitlist receiving ICHD, when compared with the seroprevalence of 14% in London, it suggests seroconversion may not be uncommon.[21]

In conclusion, as services start to recover, we must start planning for how transplantation and follow-up care are going to look to the new era. This study provides data on the outcomes of COVID-19 in transplant recipients compared with waitlist patients on dialysis at a single center. Further data sets are required to corroborate our findings, but, more importantly, we need to understand the patient's perspective. Personal experiences from the authors of this study suggest that patients are looking to us more than ever to provide informed advice, which is currently unavailable in these unprecedented times. There are likely to be considerable intercountry, intercenter, and interpatient level differences in how programs are run, but counterintuitively only collectively will we be able to complete the rehabilitation process.

APPENDIX

Senior Clinicians at the ICHNT Renal COVID Group Caring for These Patients and Collaborating With This Investigation

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DISCLOSURE

All the authors declared no competing interests.

ACKNOWLEDGMENTS

AUTHOR CONTRIBUTIONS

GL, CC, and MW conceived the project. GL, CC, SG, PM, MA, SPM, RC, MG, DA, and MW obtained samples and data. MW supervised the research. MP and MW performed the data analysis. GL, CC, and MW wrote the first draft of the article. LL, AM, and FD critically appraised the manuscript. All authors reviewed and approved the final manuscript submitted for publication.

SUPPLEMENTARY MATERIAL

Supplementary File (PDF)
Table S1. Comparison between transplant and wait listed patients.
Table S2. Details of immunosuppression being received by patients on the waitlist.
Table S3. Comparison waitlist patients with undetected and confirmed COVID-19.
Table S4. Comparison transplant patients with undetected and confirmed COVID-19.

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