Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

dialysis patients (n = 10) and nondialysis patients with normal renal function (n = 14), measured by ELISA and evaluated as the ratio to an internal control for samples with SARS-CoV-2–specific $CD4^+$ T cells. (**C**) Identification of cytokine-expressing T cells reactive to the M, N, or S protein combined: expression of Th1 cytokines IFNγ, IL-2, or TNF and granzyme B among antigen-reactive $CD4^+CD137^+CD154^+$ (upper panels) and $CD8^+CD137^+$ (lower panels) among all $CD4^+$ or $CD8^+$ cells, respectively. Groups were compared using a 2-sided, unpaired Mann–Whitney U test. *P* values ≤ 0.05 were defined as significant and are marked by an asterisk.

Figure S2. SARS-CoV-2–reactive memory T-cell phenotypes. Isolated PBMCs from dialysis (n = 14) and nondialysis patients with normal renal function as the control (n = 14) with SARS-CoV-2 infection were stimulated for 16 hours with 1 μg/ml of SARS-CoV-2 OPPs from the M (n = 13/14), N (n = 13/14), or S (n = 14/14) protein. Presented are frequencies directed against all proteins combined. (**A**) Identification of antigen-reactive memory T cells: After gating on SARS-CoV-2–reactive $CD4^+CD137^+CD154^+$ and $CD8^+CD137^+$ T cells, memory cells were identified by the expression of CD45RA and CCR7 as naïve ($CD45RA^+CCR7^+$), central-memory (CM, $CD45RA^-CCR7^+$), effector-memory (EM, $CD45RA^-CCR7^-$), and TEMRA ($CD45RA^+CCR7^-$) cells. Comparison of overall SARS-CoV-2–reactive naïve and memory (**B**) $CD4^+CD137^+CD154^+$ and (**C**) $CD8^+CD137^+$ T cells. (**D**) Distribution of naïve and memory SARS-CoV-2–memory T-cell populations. Groups were compared using a 2-sided, unpaired Mann–Whitney U test. *P* values ≤ 0.05 are marked by an asterisk.

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Antibody response to the BNT162b2 vaccine in maintenance hemodialysis patients

see commentary on page 1275

To the editor: Patients receiving maintenance hemodialysis (MHD) may have altered vaccine responses.[1] Although mRNA vaccines against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) have demonstrated dramatic efficacy in preventing symptomatic forms of coronavirus disease 2019 (COVID-19) in the nondialysis population,[2] the characterization of vaccine response in patients receiving MHD remains a major unmet need.

We studied the humoral response after the BNT162b2 mRNA vaccine using anti–spike(S)1 IgG antibody (Beckman Coulter Access; reference range for antibody positivity signal-to-cutoff >1; gray zone, 0.8–1) in a single-center cohort of 69 patients receiving MHD.

Three hundred seventy-eight samples were analyzed (Figure 1). Thirteen patients (19%) had a history of previous COVID-19 or positive baseline serology. Samples until week 6 to 7 were available for 64 patients. Overall seropositivity rate at last follow-up was 55 of 64 (86%) (Supplementary Table S1). Patients aged >70 years were less likely to reach seropositivity at last follow-up (28 of 37 [75%]; $P = 0.01$; Supplementary Table S1). Conversely, immunocompromised status did not influence the seroconversion rate (7 of 8 [87%] seropositive among immunocompromised patients). The rate of early seropositivity was associated with a history of COVID-19 (Supplementary Table S2). Since week 2, the mean anti-S1 levels of these patients were significantly higher than those of infection-naïve individuals, even after both injections (Supplementary Table S3; Figure 1a). No difference in patient characteristics was observed between both groups (Supplementary Table S3). Among infection-naïve patients, anti–S1 IgG levels progressively increased among time (Figure 1b). The seropositivity rate was 10 of 56 (18%) before the second injection and 43 of 52 (82%) at last follow-up (Supplementary Tables S3–S5). Older age was associated with a reduced late seropositivity rate (Supplementary Table S5). Interestingly, 2 infection-naïve patients developed paucisymptomatic SARS-CoV-2 infection 5 and 6 weeks after first vaccine dose. Anti-S1 titers were 0.5 and 1.4, respectively, in these patients.

In this analysis of postvaccine humoral response, patients receiving MHD have an overall anti-S1 seropositivity rate

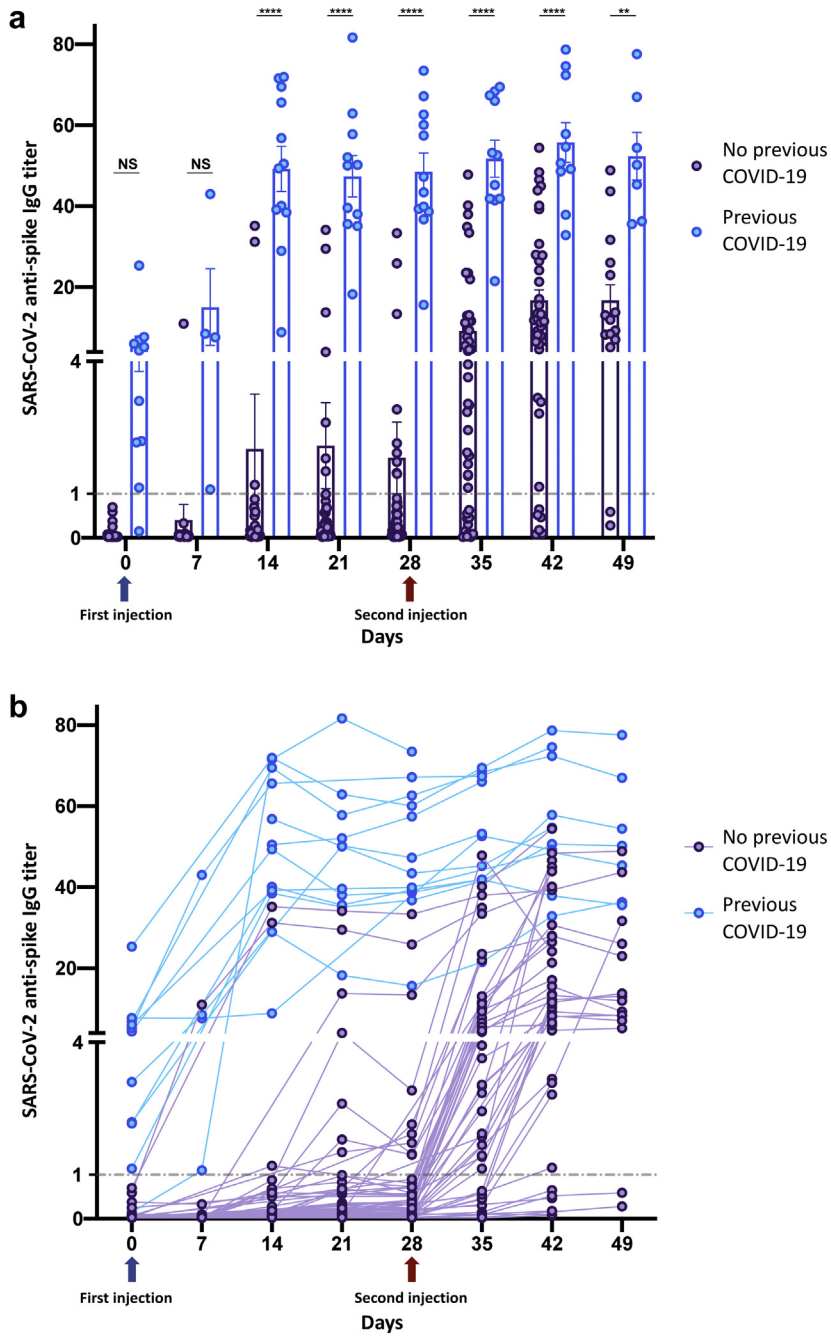

Figure 1 | Serologic response after first and second injections of the BNT162b2 mRNA vaccine in patients with or without history of coronavirus disease 2019 (COVID-19). (**a**) Comparison of the evolution of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) anti–spike antibodies over time (days) after the first (day 0; blue arrow) and second (day 28; red arrow) BNT162b2 mRNA vaccine between a group with previous COVID-19 (n = 13) and a group with no history of COVID-19 (n = 57). Scatterplot with bar is shown. Means ± SEM are shown. The cutoff for negative serology was defined according to the manufacturer (index signal-to-cutoff [S/CO] <1; dashed line). (**b**). Kinetics of the evolution of SARS-CoV-2 anti–spike antibodies over time (days) with repeated measures matched for each patient, after the first (day 0; blue arrow) and second (day 28; red arrow) BNT162b2 mRNA vaccine between a group with previous COVID-19 (n = 13) and a group with no history of COVID-19 (n = 57). Spaghetti plot is shown. The cutoff for negative serology was defined according to the manufacturer (index S/CO <1; dashed line). Statistical analysis with mixed-effect analysis with Sidak multiple-comparison test. $^{**}P < 0.01$, $^{****}P < 0.0001$. NS, nonsignificant.

>80% after 2 doses of the BNT162b2 mRNA vaccine, but only 18% after a single injection. Moreover, patients receiving MHD with a previous SARS-CoV-2 infection have a higher rate of positive anti–S1 IgG (as expected) and higher anti–S1 IgG levels, compared with infection-naïve individuals. Older age is associated with a lower seropositivity rate in our cohort. These data are probably close to those observed in patients not receiving dialysis (as for long-term humoral response

post–COVID-19[3]), although seropositivity rates appear to be lower in patients receiving MHD.[4] Although anti–S1 IgG titer is reported to correlate with *in vitro* virus neutralization,[4] postvaccine immunity longevity (including cellular immunity not studied in this work) and protection from symptomatic infection remain to be studied in patients receiving MHD.

Overall, this study suggests that most patients receiving MHD given both doses of the BNT162b2 mRNA vaccine are expected to develop an anti–S1 IgG response that may be protective.

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SUPPLEMENTARY MATERIAL
Supplementary File (PDF)
Supplementary Methods.
Table S1. Characteristics of patients according to late serologic status.
Table S2. Characteristics of patients according to early serologic status.
Table S3. Characteristics of patients according to previous COVID-19 history.
Table S4. Characteristics of infection-naïve patients according to early serologic status.
Table S5. Characteristics of infection-naïve patients according to late serologic status.

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Seroprevalence of antibody to S1 spike protein following vaccination against COVID-19 in patients receiving hemodialysis: a call to arms

see commentary on page 1275

To the editor: Adult patients with end-stage kidney disease on hemodialysis are at increased risk of coronavirus disease 2019 (COVID-19) infection and death.[1] This group is often multiracial, experiences from many comorbidities, and can be socioeconomically deprived, all factors strongly associated with COVID-19 mortality.[1] Vaccination is a priority for this at-risk group who are relatively immunosuppressed, and the effectiveness of vaccines has not been explicitly tested in patients with chronic kidney disease and on dialysis, meaning vaccine efficacy or immunogenicity is not well-understood.[2] To achieve maximum population coverage, in the United Kingdom, the second vaccine dose was delayed to 12 weeks. Retrospective review of the Oxford-AstraZeneca vaccine (AZD1222) trial data suggests that a single dose is efficacious and the delay may result in overall improved efficacy,[3] but prospective data and data on other vaccines are lacking. In health care workers, a single dose of the Pfizer-BioNTech vaccine (BNT162b2) elicited much stronger humoral and cellular responses in those with a previous natural infection.[4] Understanding the immune responses of patients receiving hemodialysis is vital to guide current and future vaccine dosing strategies in this vulnerable group.

Herein, we describe the antibody response against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) spike protein 28 days after the first dose of either the BNT162b2 or AZD1222 vaccine in 94 patients receiving maintenance hemodialysis (full methods in Supplementary Appendix S1).

Mean time between vaccination and antibody testing was 27.8 ± 4.2 days. Clinical characteristics of the study population

Table 1 | Baseline characteristics of hemodialysis patients

Clinical characteristics	Hemodialysis cohort (n = 94)
Age, mean ± SD, yr	62.1 ± 12.2
Female sex, n (%)	38 (40.4)
Race, n (%)	
Asian	47 (50)
White	35 (37.2)
Black	10 (10.6)
Mixed	1 (1.1)
Other	1 (1.1)
Diabetic, n (%)	43 (45.7)
Previous immunosuppression, n (%)	10 (10.6)
Previous COVID-19 infection, n (%)	20 (22.3)
Pfizer vaccine, n (%)	77 (82)
AstraZeneca vaccine, n (%)	17 (18)

COVID-19, coronavirus disease 2019.