Continuous Renal Replacement Therapy for a Patient with Severe COVID-19

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\section*{Abstract}
The outbreak of coronavirus disease 2019 (COVID-19) is a global health threat. It is a respiratory disease, and acute kidney injury (AKI) is rare; however, if a patient develops severe AKI, renal replacement therapy (RRT) should be considered. Recently, we had a critically ill COVID-19 patient who developed severe AKI and needed continuous RRT (CRRT). To avoid the potential risk of infection from CRRT effluents, we measured severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) genetic material in the effluents by qRT-PCR, and low copy numbers of the viral genome were detected. Due to unstable hemodynamic status in critically ill patients, CRRT should be the first choice for severe AKI in COVID-19 patients. We suggest prevention of clinical infection and control during administration of RRT in the acute phase of COVID-19 patients with AKI or multiple organ failure.

\section*{Introduction}
Acute kidney injury (AKI) is a life-threatening disorder, although the rate of AKI in COVID-19 is relatively rare. According to reports from Wuhan, China, among 138 hospitalized patients with COVID-19, only 5 (3.6\%) patients developed AKI and 2 (1.5\%) patients required continuous renal replacement therapy (CRRT) \cite{1}. There are no data about managing CRRT, including prevention of secondary infection and control (IPC) in COVID-19 patients. Here, we report a case of a patient with severe COVID-19 who required CRRT.

\section*{Case}
A septuagenarian male suffering from COVID-19 was referred to our hospital. On day 3, tracheal intubation was performed and mechanical ventilation was initiated. His \textit{sCre} gradually decreased from 1.34 mg/dL (day 1) to 1.06 mg/dL (day 6). As the urine output gradually decreased, \textit{sCre} increased from day 7 and reached 3.46 mg/dL on day 9, when CRRT was initiated. Nafamostat mesylate was used for anticoagulation. Cytokine-adsorbing polymethyl methacrylate membrane \cite{2, 3} was used as a hemofilter. During the management of CRRT, there is a risk of the presence of the virus in the CRRT effluent \cite{4}. To evaluate this possibility, we measured SARS-CoV-2 genetic material in the CRRT effluent by qRT-PCR.
at 5 different time points on 2 days (day 11 and day 14). Real-time RT-PCR for 2019-nCoV was performed at the National Institute of Infectious Diseases [5]. A very weak but positive RT-PCR result was detected in 3 of 5 specimens (Table 1). We disposed the CRRT effluent in a container using fluid coagulant agent, closed the lid, and treated it as hazardous waste. Though the patient developed anuria, X-ray showed better aeration with continuous removal of water by CRRT, and the patient was extubated on day 22.

Discussion

According to a recent report from Wuhan, China, among 52 critically ill adult patients with COVID-19 pneumonia who were admitted to the ICU, 12 (23%) patients developed AKI and 9 (17%) required renal replacement therapy (RRT) [6]. Higher morbidity has been reported among the elderly and in those with coexisting disease conditions [7]. With the increasing number of COVID-19 patients, the need for RRT is likely to increase. To prevent the spread of infection, all staff who managed CRRT wore personal protective equipment comprising standard, contact, and droplet precautions; gloves; N95 mask; gown; cap; and face shield. Although the recommendation by the WHO for the use of personal protective equipment for COVID-19 did not include CRRT [8], we considered the risk of aerosol generation during CRRT. The pore size of a hemofilter is 7–10 nm [9] and the size of 2019-nCoV is about 100 nm [10], which suggests that the permeability of 2019-nCoV into CRRT effluent is significantly low. Therefore, these results need to be evaluated in further studies. Additional examination including virus isolation should be considered to evaluate whether the effluent from CRRT is clinically infectious.

Conclusion

To the best of our knowledge, this is the first report describing the management of CRRT including IPC among COVID-19 patients. From our experience, we suggest clinical practice and IPC for delivering RRT in the acute phase in COVID-19 patients who develop AKI (Table 2).
# Table 2. Clinical practice for CRRT for COVID-19

| Parameter               | Clinical practice                                                                 |
|-------------------------|-----------------------------------------------------------------------------------|
| Staff                   | Certified doctor of blood purification in critical care                            |
|                         | Certified doctor of infectious disease                                             |
|                         | Experienced medical engineers                                                      |
|                         | Highly trained ICU nurses                                                          |
| Infection prevention and control | All staff who care for patient directly and handle CRRT equipment wear PPE: gloves, N95 mask, gown, cap, and face shield |
|                         | Patient is in an airborne infection isolation room at ICU, or designated ward      |
|                         | CRRT equipment is placed in the anteroom during priming                           |
| Access                  | Temporary double-lumen catheter placed using ultrasound                            |
| CRRT modality           | CRRT for initial treatment                                                         |
|                         | Consider transition to daytime RRT until recovery from AKI or can leave from biocontainment isolation |
|                         | PMMA or AN69ST membrane for initial hemofilter choice                               |
| Replacement solution    | Self-admixture sodium bicarbonate and sodium chloride solution (Na+ 140 mEq/L, K+ 2.0 mEq/L, Ca2+ 1.0 mEq/L, Mg2+ 1.0 mEq/L, Cl– 113 mEq/L, CH3COO– 0.5 mEq/L, HCO3– 35 mEq/L, and glucose 100 mg/dL) |
| CRRT dosing             | Deliver a total effluent dose of 20 mL/kg per hour                                  |
| Anticoagulation         | Nafamostat mesylate 30–40 mg per hour                                              |
| Effluent disposal       | Drain patient-contact effluent in the container and add a coagulant before disposal |
|                         | Wipe outside of the container with alcohol, then treated as hazardous waste, and dispose |

ICU, intensive care unit; CRRT, continuous renal replacement therapy; PPE, personal protective equipment; AKI, acute kidney injury; PMMA, polymethyl methacrylate; AS69ST, polyethylenimine-coated polycrylicnitrile.

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## Statement of Ethics

This research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. The study protocol was approved by the Institutional Review Board (approval No. NCGM-G-003472-02). Written informed consent for publication was obtained from the patient.

## Disclosure Statement

The authors have no conflicts of interest to declare.

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## Author Contributions

D.K., M.K., and T.O. conceived of the presented idea. D.K., T.O., and T.F. performed CRRT. N.K. managed the samples. H.K. and T.S. performed RT-PCR. D.K., M.K., and F.H. contributed to the final version of the manuscript. N.O. supervised the project.

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