Case Report

Blood Purification

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

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Keywords
COVID-19 · Continuous renal replacement therapy · Acute kidney injury

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.

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) [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.

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 sCre gradually decreased from 1.34 mg/dL (day 1) to 1.06 mg/dL (day 6). As the urine output gradually decreased, 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-absorbing polymethyl methacrylate membrane [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 [4]. To evaluate this possibility, we measured SARS-CoV-2 genetic material in the CRRT effluent by qRT-PCR

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Table 1. Clinical parameters and data

	Day 1	Day 4	Day 7	Day 8	Day 9	Day 11	Day 14
Event	Admission			AKI	CRRT		
sCre, mg/dL	1.34	1.34	1.25	2.08	3.46	4.52	6.21
Urine volume, mL/day		2,240	864	558	398	20	7
SOFA score		11	13	14	15	21	15
	Results of RT-PCR for SARS-CoV-2 (Ct)						
	Day 1	Day 3	Day 5	Day 7	Day 9	Day 11	Day 14
Blood	268.0 (34.73)	316.4 (34.48)	68.9 (36.78)	25.4 (38.35)	UD		UD
Pharyngeal swab	1,766.0 (31.88)				384.1 (31.4)		20.5 (35.93)
Lower respiratory tract	1,379,500.0 (21.81)	48,200.0 (26.88)	4,586.0 (30.43)		466.7 (31.11)		1,254.5 (29.57)
CRRT effluent						1 h; 19.21 (36.05) 3 h; UD 6 h; 20.72 (35.91)	1 h; UD 3 h; 12.63 (37.45)

CRRT effluent samples were taken on day 11 (1, 3, and 6 h after CRRT start) and on day 14 (1 and 3 h after CRRT start). Data are presented as virus copies per 1 μL (Ct). Lower cycle threshold (Ct) values indicate higher viral loads. RT-PCR was performed using Quantitect probe one-step RT-PCR kit (Qiagen, MD, USA) with the following probe and primer sets; WuhanCoV-spk2-f 5′-TTTCCTC-GTGAAGGTGTCTTTGT-3′, WuhanCoV-spk2-r 5′-TGTGGTTCATAAAAATTCCTTTGTG-3′, and WuhanCoV-spk2-hex-p 5′-HEX-TCAAATG-GCACACACTGGTTTGT-BHQ1 targeting spike gene (24,843–24,916 in GenBank accession MN908947); WuhanCoV-N1f 5′-GGCCGCAAATTGCACAAT-3′, WuhanCoV-N1r 5′-CCAATGCGCGACATTCC-3′, and WuhanCoV-N1pr-fam 5′-FAM-CCCCCAGCGCTTCAGCGTTCT-TAMRA-3′ targeting nucleoprotein gene (29,191–29,251 in MN908947). SOFA, sequential organ failure assessment; CRRT, continuous renal replacement therapy; AKI, acute kidney injury; UD, undetected.

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 polyacrylonitrile.

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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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