Brief Report

Frequency of Continuous Renal Replacement Therapy Use Early in Coronavirus Disease 2019 Pandemic

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Objectives: A subset of patients with coronavirus disease 2019 develop renal failure and require continuous renal replacement therapy. We reviewed the available literature to understand the frequency of continuous renal replacement therapy use among patients with coronavirus disease 2019 who required intensive care.

Data Sources: The authors reviewed PubMed and Google Scholar for published studies and MedRxiv.com for unpublished studies.

Study Selection: Observational and randomized studies that report the frequency of continuous renal replacement therapy use in adult patients with coronavirus disease 2019.

Data Extraction: Data from the eligible studies were extracted independently by two authors into Microsoft Excel.

Data Synthesis: We identified 12 eligible studies (eight published, four unpublished). We found that up to 20% of patients admitted to ICUs may require continuous renal replacement therapy.

Conclusions: Given the high utilization of continuous renal replacement therapy by critically ill patients with coronavirus disease 2019, there may be an urgent need to mobilize inpatient dialysis resources to cope with the anticipated increase in the demand.

Key Words: continuous renal replacement therapy; coronavirus disease 2019; dialysis; renal failure; severe acute respiratory syndrome coronavirus 2

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has led to a pandemic, causing coronavirus disease 2019 (COVID-19) in patients worldwide. As of April 27, 2020, COVID-19 has been reported in 185 countries, diagnosed in over 3 million cases worldwide, and led to over 200,000 deaths (1). As the new cases and healthcare utilization continue to rise, there is an ongoing discussion about increasing healthcare resources, including personal protective equipment and ventilators (2). Patients with severe COVID-19 may present with multiple organ dysfunction, including renal failure, necessitating continuous renal replacement therapy (CRRT) (3, 4). Renal injury in patients with COVID-19 may be multifactorial. Hypotension, cytokine storm, and direct viral invasion of renal cells may play a role in acute kidney failure (5). We reviewed published and unpublished literature reporting on the frequency of CRRT use in patients with COVID-19 to estimate the potential burden COVID-19 pandemic may pose on the inpatient dialysis resources.

METHODS

We sought to identify observational and randomized studies reporting on the frequency of CRRT during the inpatient admission for adults (>18 yr old) with confirmed COVID-19. PubMed and Google Scholar were searched to identify publications detailing the clinical course of COVID-19 patients, complications, and utilization of advanced therapies. The following search phrase was used in PubMed and Google Scholar: (covid-19 or coronavirus or sars-cov-2) AND (dialysis or CRRT or clinical characteristics). MedRxiv.com was searched for additional unpublished articles. All abstracts published from December 1, 2019, to April 3, 2020, were reviewed. Full texts for potentially relevant articles were read to assess for inclusion. The citations for each included article were reviewed to identify additional articles that could meet the inclusion criteria. If the relevant information was not available, the study authors were contacted by e-mail. If multiple reports used the same dataset, only the latest report was included. The search, review of abstracts and full texts, and data abstraction were performed independently by two authors (A.B., L.P.O.). The disagreements were resolved through discussion.

RESULTS

A total of 12 studies met the inclusion criteria. Eight studies had been published in peer-reviewed journals, and the other four had not yet been published or peer-reviewed. Eleven studies described patients from China, and one case series reported on patients...
requiring ICU level of care in Seattle, WA. The eight published studies included 2,447 patients, with 284 patients requiring ICU admission, and 55 receiving CRRT (Table 1) [3, 4, 6–13]. The ratio of CRRT use to ICU admissions was 19.7%. The four unpublished reports included 593 patients, with 151 patients requiring ICU admission and 36 receiving CRRT (14–17). Among all the included patients with COVID-19, about 20% of the patients who had acute respiratory distress syndrome or needed ICU admission received CRRT.

DISCUSSION
Our review highlights a high utilization of CRRT use among patients with COVID-19 who require ICU level of care. The CRRT use in ICU patients varied from 5.6% to 61%; thus, the overall estimate of 20% may be imprecise. The variation in CRRT use may reflect the differences in the duration of follow-up, the spectrum of illness in the included patients, heterogeneity in local ICU patient flow and policies, and available resources. We contacted the primary study authors to understand the policies around the dialysis allocation, a potential confounder of the frequency of CRRT use. The authors noted that clinical judgment was the primary driver of the dialysis resource allocation, which may explain some of the variability.

The vast majority of data on early experience with COVID-19 is based on data from China. Thus, the external validity to other settings is a limitation of this study. We searched for the additional publications from the review censorship date through April 26, 2020. We identified two relevant publications from New York, United States. These studies included 6,093 patients with 1,409 patients requiring ICU level care and 242 requiring CRRT (18, 19). Combined with the data from Seattle, WA, reported in this study, the rate of CRRT use in ICU patients in the United States is 244/1,433 (17%), similar to the rate found from the included studies.

The overall CRRT utilization may be underestimated as the patients who remained in the ICU at the time of data extraction may have required CRRT later in their hospital course. Additionally, there is a concern that there are duplicate patients in multiple studies from China (20). Although an effort was made to exclude those studies, it is still possible that individual patients are represented more than once in the summary estimate.

Many questions remain unanswered. It is unclear how often patients experienced complications such as venous thrombosis

### TABLE 1. Patients With Coronavirus Disease 2019 Admitted to ICU Who Require Continuous Renal Replacement Therapy

| Reference, Journal, Journal Setting | Patients in ICU/Total Patients | Patients With Acute Respiratory Distress Syndrome | Continuous Renal Replacement Therapy Use/ICU Patients (%) |
|------------------------------------|-------------------------------|-----------------------------------------------|----------------------------------------------------------|
| Published                          |                               |                                               |                                                          |
| Bhatraju et al (6), *NEJM*         | Seattle, United States        | 24/24                                         | 18                                                       | 2/24 (8)*                                             |
| Cao et al (7), *Int Care Med*      | Wuhan, China                  | 18/102                                        | 20                                                       | 6/18 (33)                                             |
| Chen et al (8), *Lancet*           | Wuhan, China                  | 23/99                                         | 17                                                       | 9/23 (39)                                             |
| Guan et al (4), *NEJM*             | China (multisite)             | 55/1,099                                      | 37                                                       | 9/55 (16)                                             |
| Huang et al (9), *Lancet*          | Wuhan, China                  | 13/41                                         | 12                                                       | 3/13 (23)                                             |
| Liu (10), *J Infect*               | Hainan, China                 | 9/56                                          | 6                                                        | 5/9 (56)                                              |
| Wang et al (11), *JAMA*            | Wuhan, China                  | 36/138                                        | 27                                                       | 2/36 (6)                                              |
| Yang et al (12), *Lancet Respir Med* | Wuhan, China                  | 52/52                                         | 35                                                       | 9/52 (17)                                             |
| Zhang et al (13), *Int J Infect Dis* | Zhejiang, China              | 4/645                                         | 14                                                       | 0/4 (0)                                               |
| Zhou et al (3), *Lancet*           | Wuhan, China                  | 50/191                                        | 59                                                       | 10/50 (20).                                            |
| Total                              | 284/2,447                     | 245                                           | 91/284 (20.9)                                            |
| Unpublished                        |                               |                                               |                                                          |
| Liu et al (14), *medRxiv*          | Guangdong, China              | 26/291                                        | 3                                                        | 5/26 (19)                                             |
| Xu et al (15), *medRxiv*           | Guangdong, China              | 45/45                                         | 37                                                       | 4/45 (9)                                              |
| Yang et al (16), *medRxiv*         | Wuhan, China                  | 36/36                                         | 36                                                       | 22/36 (61)                                             |
| Zhang et al (17), *medRxiv*        | Wuhan, China                  | 44/221                                        | 48                                                       | 5/44 (11)                                             |
| Total                              | 151/593                       | 124                                           | 36/151 (23.8)                                            |
| Combined total                      | 435/3,040                     | 369                                           | 91/435 (20.9)                                            |

*Information was not available in the article, obtained by e-mailing the corresponding author.*
at access sites, clotting of dialysis lines, or what proportion of those patients required continued dialysis after the hospitalization. There is a need for comprehensive data on CRRT complications and long-term outcomes in patients with COVID-19. As the number of patients with COVID-19 admitted to ICU continue to rise rapidly, we should anticipate a significant strain on inpatient hemodialysis units providing CRRT or intermittent hemodialysis to hospitalized patients. Among many potential measures, systemic interventions such as 24-hour staffing of inpatient dialysis units and obtaining more dialysis machines may be required to provide the needed care to inpatients.

The authors have disclosed that they do not have any potential conflicts of interest.

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