Perspective

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Impending Shortages of Kidney Replacement Therapy for COVID-19 Patients

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Practicing nephrology in New York City, at the epicenter of the novel coronavirus disease 2019 (COVID-19) pandemic in the United States, we have been struck by the continued focus on the concern that a critical deficiency of ventilators will occur. Our efforts in the past weeks have led us to fear that another critical shortage may occur before that of ventilators: our ability to deliver KRT for patients severely affected by COVID-19. We and other centers in New York are encountering significant challenges to delivering *any* form of KRT to the many patients with COVID-19 and AKI or kidney failure. To our knowledge, these challenges have been under-reported in the media and not acknowledged explicitly by public health officials or elected representatives.

The sparse data available on this subject suggest that the incidence of AKI in all people infected with SARS-CoV-2 is as low as 0.5% (1). This value belies what we observe in New York's medical centers: the incidence of AKI in critically ill, hospitalized patients with COVID-19 is far higher. The possible causes of AKI in patients infected with COVID-19 have recently been reviewed (2). An informal survey of our intensive care units (ICUs) this week demonstrates that 20%–40% of intubated ICU patients have AKI that necessitates KRT. For example, to demonstrate the magnitude of our workload, Bellevue Hospital Center has 105 patients with COVID-19 in the ICUs, with 44 with AKI, 40 of whom required KRT; outside the ICUs, there are 276 patients with COVID-19, with 32 seen by the nephrology consult service, 22 of whom have kidney failure. The proportions are similar at Tisch Hospital and the New York campus of the New York Harbor VA, which have more and fewer total patients, respectively, in those categories. This high incidence of COVID-19–associated AKI is true for the full range of the demographically diverse patients we care for at New York University (NYU) Langone-Manhattan campus (the university hospital of NYU Langone Health), NYU Langone Hospital–Brooklyn, Bellevue Hospital Center (the largest of New York's public hospitals), and the New York campus of the New York Harbor Veterans Affairs Health Care System. On the basis of exchanges with our nephrology colleagues, it also reflects what is being seen at all of the medical centers, big and small, in New York.

Our most acute problem, because of the surge of patients, is that capacity for delivering KRT is stretched to the point of nearly breaking. The possibility that this eventuality would occur in this pandemic was presciently foreseen in a recent article that described ways of mitigating the effects of the high incidence of AKI (3). On a normal day, our medical centers deliver many hemodialysis treatments and provide ample continuous KRT (CKRT) to meet the needs of hospitalized patients, but the needs have increased several-fold. In mid-March 2020, our contingency planning for COVID-19 did not foresee the increased extent to which these modalities would be needed, or the myriad hurdles to expanding capacity. Perhaps most important is the reduced numbers of trained staff available. Our hemodialysis nurses, like many health care workers in areas affected by the pandemic, became ill with COVID-19 and stayed home in isolation. Our contracted hemodialysis machine maintenance staff were also quarantined at times, preventing them from addressing machine dysfunction in a timely fashion. The skills required to perform hemodialysis are not readily acquired by previously untrained health care workers. Our hardworking nurses and technicians can provide only so many hemodialysis treatments per day in the ICUs of our hospitals, which have continually seen increasing numbers of admissions. The widespread geographic nature of the pandemic precludes hiring temporary hemodialysis staff. We reduced the frequency of hemodialysis for many patients with kidney failure treated in hospital-based dialysis facilities from three to two times per week, and the duration of therapy from 4 to 3 hours. These strategies were helpful, particularly as we acquired new patients with kidney failure—some with COVID-19—but they meant delivering a suboptimal prescription. We also experienced an at-least temporary loss of nephrologists to COVID-19 infection, increasing our own risk of burnout, although the loss is less limiting than the loss of nurses and technicians.

Our utilization of CKRT in the ICUs has increased dramatically. We now have 11 machines at NYU Langone-Manhattan campus, six at Bellevue Hospital Center, and four at NYU Langone Hospital–Brooklyn. In these numbers of treatments, the modality places strains on ICU nurses. It constitutes a problem when the

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Table 1. Impediments to delivery of adequate KRT

High incidence of AKI in affected patients
Responses
Anticipatory contingency planning (3,5)
Regular virtual meetings and calls with administrators to review workload and needs
Loss of hemodialysis personnel to COVID-19
Responses
Initiate more CKRT
Initiate acute peritoneal dialysis
Train nonhemodialysis staff
Recruit volunteers
Safely reduce frequency and duration of hemodialysis for patients with kidney failure
Transfer of patients with hemodialysis from hospital-based units to community dialysis units
Relative inexperience of some personnel with placement of peritoneal dialysis catheters
Responses
Encourage surgeons, radiologists, and nephrologists with experience to train additional staff
Relative inexperience of ICU staff and dialysis staff with performance of peritoneal dialysis
Responses
Construct teams of non-ICU, nondialysis staff to help manage manual exchanges
Obtain cyclers to help automate exchanges and reduce risks of staff exposures
Shortages of supplies of KRT supplies
High national and local demands put stress on vendors
CKRT machines, cartridges, and fluid
Hypercoagulability leads to loss of cartridges and lines
Peritoneal dialysis fluid
Responses
Develop relationships with vendors to anticipate needs and ensure delivery of equipment and supplies
Perform accelerated venovenous hemofiltration to get two treatments per day from each CKRT machine if sufficient supply of cartridges is available
Perform fewer peritoneal fluid exchanges as blood values correct
Resistance of overworked staff to learning new procedures or use of new equipment
Responses
Be patient, constructive, and collaborative in developing teams

COVID-19, novel coronavirus 2019; ICU, intensive care unit; CKRT, continuous kidney replacement therapy.

number of ICU beds and ventilated patients is expanded by decreasing nurse-to-patient staffing ratios. We also had to procure more machines. To provide KRT to two patients per day with each machine, we also instituted accelerated venovenous hemofiltration (4). Nationwide and regional increases in usage have caused unanticipated shortages for consumable CKRT supplies. Short-lived scarcity of continuous venovenous hemofiltration cartridges and fluid, and uncertain long-term prospects for maintaining supplies commensurate with anticipated needs, have occupied us on a daily basis.

We purchased three Tablo dialysis machines at VA, with more coming to NYU Langone-Manhattan Campus, hoping that their flexibility to provide conventional hemodialysis and CKRT, and their user-friendly interface, would augment our capacities. Training nondialysis staff and nephrologists to use them and getting preparatory water testing accomplished are modest impediments to their implementation, requiring at least 2 weeks. Modifications of facility plumbing allowed extension of dialysis modalities to additional sites and new ICUs.

We initiated the use of acute peritoneal dialysis, a modality rarely used in American ICUs in recent years, to remove pressures from our CKRT supply and hemodialysis staff. We were fortunate that our surgeons adapted quickly to our increased demand. At Bellevue Hospital Center, we had 22 patients on daily peritoneal dialysis, at New York Campus of the New York Harbor VA Healthcare System, we had six patients on daily peritoneal dialysis, and at NYU Langone-Manhattan Campus, we had four patients on daily peritoneal dialysis. The technique has had some success, but introduces many practical problems. As in many United States centers, few of our ICU nurses have experience performing peritoneal dialysis and understandably resist learning a new procedure under already trying circumstances. Adequate delivery of frequent manual exchanges of peritoneal dialysate has been intermittent, often reduced for long periods, especially at night when staffing is less abundant. Larger volumes of dialysate exchanges were not as adverse for ventilation as we initially feared. We have creatively resorted to training teams of non-ICU health care workers (including physicians from other specialties) to assist, but finding personnel to be present around the clock is currently difficult. As the number of patients receiving peritoneal dialysis has increased, supplies of dialysate have become uncertain. Pleas to our vendors have been successful thus far, but they, in turn, are limited by commitments to patients with kidney failure who dialyze with ambulatory peritoneal dialysis regimens. The long-term viability of this option is uncertain. Although we anticipate eventually using more peritoneal dialysis cyclers, we recognize that they will require additional training of various inexperienced staff. Currently we have two cyclers at NYU Hospital–Brooklyn, two at Bellevue Hospital Center (with a plan to lease 18 more), and none at Tisch Hospital or New York Campus of the New York Harbor VA Healthcare System.

The magnitude of this calamitous short-coming in KRT could not have been foreseen by the nephrology and ICU

communities, as early and subsequent reports from China did not emphasize the problem. The result of our experience is that we must now highlight the possibility that before a deficiency of ventilators become an issue in caring for patients with COVID-19, provision of KRT may face critical shortages. This occurrence is particularly likely in the absence of national or regional efforts to increase supply and ensure that fluids and consumables are delivered to those centers with the most pressing needs. Contingency planning is appropriate and must be instituted now by medical centers that may soon face the full strength of this pandemic (3,5) (Table 1).

Guidance on the ethical principles used to allocate scarce resources focuses on the possible scarcity of ventilators, as promulgated by the New York State Task Force on Life & the Law (6). More recently, and in response to the current pandemic, a brief framework for allocation of ventilators and critical care beds has been introduced (7). Fortunately, as of the time of writing, such allocations of resources have not been required in New York at our institutions. Rather than provide recommendations regarding allocation of dialysis modalities should they be available in short supply, current guidelines tentatively suggest that patients with kidney failure be *excluded* from receiving ventilatory assistance because "renal failure increases morbidity and mortality in the ICU, and dialysis places increased demand on scarce nursing resources." Our experience suggests that medical centers must actively consider how to balance the effort to provide KRT care for all comers without compromising the ability to deliver optimal or even adequate KRT to patients with survivable acute and CKD. We think it is time for medical authorities and ethicists to consider explicitly considering the possibility that KRT will have to be allocated at this time and in future public health disasters. Our ability to ration or triage medical resources is affected by local, hospital, and state policies, and laws. The complex assessments of the relevant guidelines will be made by practitioners, attorneys, administrators, and committees, which should include nephrologists as active participants. The Strategic National Stockpile has received attention regarding its ability to supply ventilators and personal protective equipment to America's medical centers. It may be time now for it to consider stockpiling equipment for KRT. It may also be appropriate to train a larger segment of American health care workers to provide these potentially life-saving modalities in situations like the one we currently face.

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