

Providing care to patients with acute kidney injury and COVID-19 infection: Experience of front line nephrologists in New York

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Introduction

Governor Cuomo recently stated, *“We will lose people –the virus takes the most vulnerable. The challenge is to make sure we don’t lose anyone else we could have saved.”*

Severe acute respiratory syndrome coronavirus 2, known as COVID-19, was first described in China in December 2019¹. A global pandemic followed in the months to come, leading to devastating consequences. By April 26, COVID-19 has spread to more than 200 countries, infecting more than 2.9 million people, resulting in greater than 200,000 deaths globally². The suspected index case of COVID-19 infection leading to the New York City/Westchester outbreak was described in a man who became ill on February 22. By the third week of March, New York City became an epicenter of COVID-19 outbreak in the United States. Nearly 1 million Americans have been infected with the virus and New York accounts for 29% of these infections. Never in our lifetime have so many people fallen ill simultaneously. The rapid increase in hospitalizations has challenged the delivery of healthcare in unprecedented ways. Acute kidney injury (AKI) has been reported in up to 25% of patients with severe COVID-19 infection³⁻⁴. The volume of patients with severe AKI in a single hospital poses unique challenges for the nephrologist including 1) infection prevention 2) workforce 3) dialysis resources and 4) communication. We report our experience providing care to hospitalized patients with AKI in the Bronx during the first month of the outbreak.

The Bronx Experience: Acute kidney injury in COVID-19 infected patients

Montefiore Medical Center (MMC), located in the North Bronx in close proximity to Westchester County, has been one of the main urban tertiary care centers for patients in New York City with Covid-19 infection. Montefiore’s two main campuses are Moses and Weiler Hospitals. Moses Hospital is a 726-bed hospital with 5 intensive care units (47 beds) and Weiler Hospital is a 431-bed hospital with 2 intensive care units (32 beds). Each hospital has 10 clinical nephrology faculty and 4 nephrology fellows. Moses and Weiler Hospitals have 20 and 12 full time dialysis nurses, respectively. Prior to COVID-19, there were 2 nephrology consult services and 2 end-stage kidney disease (ESKD) services at Moses Hospital and 1 nephrology consult service and 1 ESKD service at Weiler Hospital. One nephrologist with a fellow or physician assistant staffed each service. The average number of consults for AKI was 10-15 per day at each hospital and average census of each consult service was 20-25 patients.

On March 10, the first confirmed COVID-19 infected patient was transferred from Westchester to MMC. This patient had AKI and immediately required renal replacement therapy (RRT). By April 6, the number of COVID-19 patients increased to 877. Simultaneously, there was a significant increase in the number of consults for AKI associated with COVID-19 infection and in those who needed acute RRT. (Table 1) Between March 10 and March 30, there were 112 nephrology consults for AKI. The average age of these patients was 63 years; 69% were men, the majority were black or hispanic, and diabetes mellitus, hypertension, chronic kidney disease and obesity were prevalent comorbidities. Most presented to the emergency department with AKI or started to develop AKI within 24 hours of admission, underscoring their severity of illness at presentation. The average time to RRT was 7 days and the most common indications for RRT were hyperkalemia and volume overload. Approximately 54% required ICU admission and 46% required RRT. To handle these high acuity patients, the number of ICU beds increased by 60% and the number of nephrology services was expanded. (Table 1)

Table 1. Census for new AKI consults, acute RRT, and hospitalized patients with COVID-19 at Montefiore Medical Center				
	March 10-16	March 17-23	March 24-30	March 31-April 6
New AKI Consults	12	38	62	78
Acute RRT	4	10	52	75
Hospital Census	2-18	26-163	233-560	625-877
Intensive care units	7	7	9	16
Nephrology Services	6	6	8	10

RRT, renal replacement therapy

A Nephrology Task Force was created to develop strategies to handle workflow and the expanding census of patients with AKI and acute RRT. (Table 2)

Table 2. Timeline and Evolution of Strategies for Treating AKI in COVID-19 Infected Patients	
March 16	<ul style="list-style-type: none"> • Formation of Nephrology Task Force • Back-up schedules created • High risk staff shifted from inpatient services to lower risk settings
March 17	<ul style="list-style-type: none"> • Purchased additional CRRT and HD machines
March 18	<ul style="list-style-type: none"> • Installation of additional dialysis compatible plumbing for bedside dialysis • Tubing extension for CRRT machine to place outside the room <ul style="list-style-type: none"> ○ NxStage Fresenius CAR 502 – 4.5 feet extension
March 21	<ul style="list-style-type: none"> • Reduction in HD frequency and treatment time in patients with end-stage kidney disease who could tolerate that schedule <ul style="list-style-type: none"> ○ Twice weekly HD for 2.5 hours with low K bath ○ Typical schedule: Monday-Thursday, Tuesday-Friday, Wednesday-Saturday • Potassium binders in patients with normokalemia (K > 4 meq/L) but rising potassium level <ul style="list-style-type: none"> ○ Sodium zirconium cyclosilicate 10g daily ○ Patiomer 8.4g daily, uptitrated to 16.8 or 25.5g as needed • Diuretics to maintain euvolemia <ul style="list-style-type: none"> ○ Furosemide 80mg IV q8-12hr or Bumetanide 2-4mg IV q12hr with Chlorthiazide 250mg IV q12hr in those with severe AKI and fluid overload • PIRRT treatments to allow treatment of 2-3 patients per day with 1 CRRT machine <ul style="list-style-type: none"> ○ NxStage machine, CVVHD ○ Blood Flow Rate: 250 mL/hr for CVVHD and 300-350 mL/hr for PIRRT ○ Effluent flow rate 25mL/kg/hr in CVVHD and 40-50 mL/kg/hr in PIRRT ○ Treatment time: 24 hours for CVVHD and 6-12 hours for PIRRT ○ Dialysate fluid – RFP 400 (2K bath), RFP 401 (4K bath)

March 24	<ul style="list-style-type: none"> Recovering COVID-19 patients without a fever for at least 3 days started to be cohorted together on last inpatient HD shift followed by terminal disinfection
March 27	<ul style="list-style-type: none"> Near capacity for inpatient HD due to majority requiring 1:1 nursing care Tele-monitoring during HD treatments to minimize nurse exposure First patient started on acute PD Expanded inpatient nephrology services
March 29	<ul style="list-style-type: none"> Inpatient HD unit started to open on Sundays Increased from 1 to 3 on call dialysis nurses Expansion and creation of 11 new COVID-19 Intensive Care Units
March 30	<ul style="list-style-type: none"> PD program initiated to increase capacity for acute dialysis <ul style="list-style-type: none"> Typical manual PD initial prescription: 1-2 liter dwells every 2-4 hours PD cyclers ordered to begin automated PD Inpatient E-consults for nephrology went live
April 1	<ul style="list-style-type: none"> Creation of acute PD service Nephrologist in-service on performing PD exchanges to assist nursing staff
April 2	<ul style="list-style-type: none"> Perfusionist reappointed to assist with PIRRT/CRRT Initiated Bivalirudin anticoagulation protocol for PIRRT/CRRT clotting <ul style="list-style-type: none"> Bolus: 0.50 mg/kg bolus 1 hour prior to PIRRT/CRRT Maintenance: 0.25mg/kg/hour 30 minutes prior to PIRRT/CRRT Stop 1 hour prior to end of PIRRT Check activated clotting time 15 minutes into treatment and PTT 4 hours into treatment Goal PTT 1.5-2x normal
April 5	<ul style="list-style-type: none"> Nephrologists training nurses to perform PD Started to use PD cyclers (Baxter) <ul style="list-style-type: none"> Typical prescription: 5 exchanges of 1.8-liter volume over 10 hours with 1.5-hour dwell time Nephrologists began assisting in performing HD due to nursing staff shortage from illness <ul style="list-style-type: none"> Primed the machines, monitored patients on dialysis, applied pressure to the access at the end of treatment
April 9	<ul style="list-style-type: none"> Majority of both hospitals COVID-19 positive, all patients now being dialyzed in the inpatient HD unit

CRRT, continuous renal replacement therapy; CVVHD, continuous venovenous hemodialysis; PIRRT, prolonged intermittent renal replacement therapy; HD, hemodialysis; PD, peritoneal dialysis; PTT, partial thromboplastin time

Infection prevention

Mitigating transmission of COVID-19 infection to other patients and hospital staff has been a major priority. To prevent spread of infection, initially all COVID-19 infected patients requiring RRT received hemodialysis (HD) treatments at bedside. In order to expand the capability of providing bedside HD, hospital rooms were re-plumbed for access to the central reverse osmosis (RO) system, portable RO were used and 10 additional HD machines were purchased from Fresenius. A limitation in providing bedside HD was the requirement of 1:1 nursing. As the number of COVID-19 infected patients increased, there was also a 2-3-fold increase in the number of patients requiring bedside HD. To accommodate the increase in patients requiring bedside HD, ESKD patients were placed on a twice weekly schedule and treatments were shortened using higher blood and dialysate flow for those who could tolerate it. Those with AKI were managed with maximal medical management to delay RRT initiation. A novel approach to prevent or slow hyperkalemia from developing was initiation of potassium binders (patiromer or sodium zirconium cyclosilicate) in patients with a serum potassium

between 4.0-5.0 meq/L that was rising. Non-oliguric patients were placed on diuretics to maintain euvolemia.

Whenever possible, the number of staff entering infected patient rooms was limited to minimize exposure and preserve personal protective equipment (PPE). Nephrology teams performed remote assessment by reviewing the electronic record, laboratory data and imaging. The most common reason for the nephrologist to directly interact with a COVID-19 infected patient was to discuss initiation of RRT or to place acute dialysis access. Tele-monitoring was piloted using baby monitors with two-way video and audio positioned next to the patient and dialysis machine, allowing the nurse to monitor the patient remotely during treatment. Tubing extension for continuous renal replacement therapy (CRRT) was purchased to allow positioning of CRRT machines outside of the ICU rooms so the nurses could adjust ultrafiltration rates and check on machine alarms without the need to put on PPE to perform this task. Despite these interventions, capacity was reached in providing bedside HD near the end of March. After consultation with infection control, the CDC recommendation to cohort COVID-19 infected patients together on the last shift of the day in the inpatient HD unit was used⁵⁻⁶.

Workforce

By the third week of March, the volume of patients with COVID-19 associated AKI and acute RRT needs increased significantly. Nephrology services were expanded to handle the increase in consults for AKI. Moses Hospital increased from 4 to 7 services and Weiler Hospital increased from 2 to 3 services. The average daily census of each service was 20-25 patients. Providers identified as high risk for severe complications from COVID-19 infection (greater than 65 years old or pregnant) were relocated from inpatient services to lower risk settings including night call coverage, electronic inpatient nephrology consults and outpatient office and hemodialysis telemedicine visits. Further complicating staffing was more than a 50% reduction in available dialysis nurses and technicians due to illness for 2 weeks. As a result, nephrologists assisted with HD by priming the machines, monitoring patients during the dialysis treatments and achieving hemostasis to the access at the end of the treatment. On March 29, the inpatient HD unit opened on Sundays to meet the number of patients requiring acute RRT.

Dialysis Resources

The availability of dialysis resources decreased due to the surge in COVID-19 patients with AKI requiring RRT⁷. CRRT is the preferred treatment modality in patients presenting with acute respiratory distress syndrome (ARDS) requiring intubation and prone positioning. However, patients with this presentation quickly depleted the ability to provide CRRT for 24-hour periods per patient. Treatment times were reduced and dialysate flow rates were increased to convert CRRT to prolonged intermittent renal replacement treatments (PIRRT). PIRRT was performed for 6-12 hour treatments with effluent flow rates of 40-50 ml/kg/hr. This permitted use of 1 machine for 2-3 patients with time for disinfection in between patients. Despite these adaptations, the surge in patients required creation of 11 additional ICUs. As a result, the nurse to patient ratio increased significantly which made it impossible for ICU nurses to manage 1:1 nursing requirements for PIRRT. Perfusionists who ordinarily manage extracorporeal membrane oxygenation procedures were reassigned and assumed the role of PIRRT management during the day. Prior to the International Society of Thrombosis and Hemostasis guidance for the recognition and management of the hypercoagulable state in patients with COVID-19, ICU patients on CRRT were observed to have increased clotting of catheters and filters despite therapeutic heparin infusion (PTT 2x normal) which led to frequent treatment interruptions and difficulty in achieving adequate clearance.⁹ To resolve the issue with clotting on CRRT, a non-validated bivalirudin protocol was initiated with close monitoring of PTT⁸.

By early April, our COVID-19 RRT census included 25-30 patients with AKI on CRRT or PIRRT, 20 patients with AKI on HD and 65 ESKD patients on HD. To meet the increasing need for acute RRT, an acute peritoneal dialysis (PD) service was created. Transplant surgeons placed Tenkhoff catheters at bedside in intubated patients and interventional radiologists placed catheters in floor patients via fluoroscopy. Within 1 week, 18 patients were initiated on acute PD. Manual PD exchanges were initiated immediately after catheter placement using 1-2 liter dwells with exchanges every 2-3 hours. Major barriers identified in effective delivery of this modality have been nurse training and frequent prone positioning of ventilated patients. To overcome these barriers, nephrologists and fellows received in-service training on how to perform manual PD exchanges and

have been assisting nursing staff with limited experience. Additionally, PD cyclers were purchased from Baxter which reduced workload and staff exposure. The majority of patients with AKI requiring acute RRT who were selected for PD were non-intubated, hemodynamically stable patients. CRRT or PIRRT was preferentially used in patients who were hemodynamically unstable, those requiring prone positioning for ARDS and those with severe electrolyte abnormalities.

Communication

Bedside evaluation has plays an important role in AKI management. However, during the COVID-19 pandemic there has been a shortage of PPE. In an effort to preserve PPE, daily patient contact by specialists has been minimized. This has been a challenge, as intravascular volume assessment is important in determination of need for IV fluids, diuretics or RRT in those with AKI. Many patients with COVID-19 associated AKI also present with respiratory failure and chest x-ray findings of bilateral lung opacities with a ground glass appearance that is difficult to distinguish from pulmonary edema. In these patients, the desire to reduce hypervolemia to optimize respiratory status must be balanced against over-diuresis which may further exacerbate AKI. Point-of-care ultrasound has been useful in assessing intravascular volume status, as well as frequent communication with the primary teams and reliance on their physical exam findings. To limit indwelling bladder catheters, nurses have been performing bladder scans to rule out urinary retention and determine urine output for intake and output assessment.

Conclusion

"Often out of periods of losing come the greatest strivings toward a new winning streak."

Despite the enormous challenges faced during the COVID-19 pandemic, this experience has taught us how to be resourceful in maximizing availability of acute AKI and RRT services to meet the needs of our patients, even in the most trying circumstances. The best advice we can offer from New York to nephrologists across the world where COVID-19 may still be in its early stages is the following: plan ahead, get creative, support each other and work together. Hopefully we will never see another pandemic in our lifetime but if we do...we will be prepared.

Acknowledgments

We would like to thank our Nephrology Task Force including Dr. Michael Ross, Dr. Maureen Brogan, Dr. Maria Coco, Dr. Michele Mokrzycki, Dr. Ladan Golestaneh, Dr. Deep Sharma, Dr. Enver Akalin, Louis Tingling MSN, and Cathy Cahill RN for their incredible hard work and dedication to patient care.

Author Contributions

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Funding

None

Disclosures

All authors have nothing to disclose.

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Figure Legend

Figure 1. Management Considerations in COVID-19 Patients with AKI

Selection of the management strategy for AKI associated with COVID-19 infection depends on several factors.

1. Patient factors including hemodynamic stability, volume status, acid-base status, candidate for acute central venous catheter insertion vs PD catheter, goals for fluid removal and clearance of uremic toxins, 2. Nursing staff availability and expertise, 3. Supply inventory of machines and materials, 4. Location of RRT procedure including appropriate HD plumbing, need for isolation precautions, patient transport safety to avoid transmission to others.

HD, hemodialysis; CRRT, continuous renal replacement therapy; SLED, sustained low efficiency dialysis; PIRRT, prolonged intermittent renal replacement therapy; PD, peritoneal dialysis

