

COVID-19 and the Inpatient Dialysis Unit

Managing Resources during Contingency Planning Pre-Crisis

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Introduction

Much has been written about disaster preparedness for dialysis units during crises such as earthquakes, floods, and hurricanes where many people in a relatively localized geographic area are affected. The Institute of Medicine defines crisis surge as “*Adaptive spaces, staff, and supplies are not consistent with usual standards of care, but provide sufficiency of care in the setting of a catastrophic disaster (i.e., provide the best possible care to patients given the circumstances and resources available). Crisis capacity activation constitutes a significant adjustment to standards of care.*” (1). The COVID-19 pandemic presents a new twist to crisis surge management in dialysis units, with the entire world dealing with the same crisis nearly concurrently. Worldwide supply and demand mismatches of resources are a particular concern. More workforce out sick or furloughed to help with social distancing leads to decreased production of supplies. Currently, patients with kidney failure on maintenance dialysis with suspected or confirmed COVID-19 infections are being triaged to hospitals, which will increase the number of hospitalized dialysis patients. There are reports that suggest that COVID-19 affects the kidneys and a high degree of AKI requiring RRT has been seen in critically ill patients (2,3). COVID-19 infections are also likely to decrease the staff we have to dialyze these patients. At some point, the demand will overwhelm supply and contingency plans will need to be implemented. In this paper, we discuss how during a crisis, such as the COVID-19 pandemic, inpatient dialysis units can spread resources to be able to treat as many patients as possible.

Dialysis Supplies

Inpatient dialysis units may be about to become a resource-constrained environment and rationing strategies need to be considered (Table 1). Conservation strategies including permissive underdialysis in the inpatient unit, with shortening of dialysis treatment time to 3 hours in all stable patients, will allow the implementation of additional shifts. Decreasing the dialysate flow rate to a maximum of 600 ml/min daily to further save dialysate will save supplies needed for dialysate (4). As a next step, in case of shortage of commercially prepared continuous RRT

(CRRT) dialysis fluids, standard “recipes” exist for hospital pharmacies to prepare them, and peritoneal dialysis fluid may also be considered as a possible replacement fluid. If needed, kidney failure patients on hemodialysis (HD) three times weekly could be moved to twice-weekly dialysis as medically permitted, thereby increasing treatment volume capacity up to an additional 50%.

Hospitalized kidney failure patients should be managed by zealous control of fluid and electrolyte intake to minimize indications for dialysis to conserve dialysis materials. In addition, intensive use of diuretics (including total nephron blockade) can be used in those with residual kidney function to treat volume overload, especially in patients with heart failure. Hyperkalemia should be managed with potassium binders and the hospital or system’s Pharmacy and Therapeutics Committee is essential, and must be engaged early. Metabolic acidosis can be managed with oral alkali replacement and diuresis.

Human Resources

Workforce issues may be particularly challenging. Nurses and technicians may be out due to illness or quarantine. Depending on an individual hospital or health system’s relationship with external dialysis organizations, there may be the ability to emergently credential outpatient dialysis nurses in your area to work in the inpatient setting, employment issues notwithstanding. Doing this will require flexibility from the local dialysis organizations, but the nephrologist is uniquely poised to appropriately argue for the needs of our patients across traditional organizational boundaries. In addition, nephrologists can also work with regional disaster management organizations to ensure that the responsibility of caring for patients with kidney failure is balanced across the region.

Decreasing dialysis nurse exposure to patients with COVID-19 is another strategy to preserve the workforce. Preferentially utilizing CRRT for patients in the intensive care unit (ICU) that are infected with COVID-19 may help decrease the number of nurses out with illness. In addition, extension tubing can be used so that the CRRT machine can be run outside the patient’s room, decreasing the need for the ICU nurse to enter the room as frequently. Patients are likely to

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Table 1. Practical ideas for increasing dialysis surge capacity

Fluid restriction	500–750 ml/d (approximately 10 ml/kg per day)
Potassium resins	Sodium polystyrene sulfonate Patiomer: 8.4 g daily; at weekly intervals can be increased or decreased by 8.4 g/d up to a maximum of 25.2 g/d Sodium zirconium cyclosilicate: 10 g three times daily for 48 h
Oral non-potassium-containing alkali therapies	Oral sodium bicarbonate available as tablet or as baking soda: 7.7 mEq HCO ₃ per 650 mg tablet 29 mEq HCO ₃ per 1/2 teaspoon baking soda Sodium citrate-citric acid solution: 5 mEq HCO ₃ per 5 ml solution
Total nephron blockade	Loop diuretic + carbonic anhydrase inhibitor + thiazide diuretic + mineralocorticoid receptor inhibitor (other strategies exist) In the setting of significant kidney impairment, consider using: Furosemide 200 mg intravenously every 6 hours + acetazolamide 250 mg by mouth every 8 hours + metolazone 10 mg by mouth twice a day + spironolactone 100 mg by mouth twice a day
Intermittent HD	Limit dialysis treatment duration to 3 hours for most treatments Limit dialysate flow rate (daily) to 600 ml/min Use twice-weekly dialysis, with proposed schedules: Monday–Thursday; Tuesday–Friday; and Wednesday–Saturday
CRRT replacement fluid recipe	1 L 0.9% NaCl with KCl as needed +1 L D5W with 150 mEq NaHCO ₃ +1 L 0.9% NaCl with 1 g MgCl ₂ +1 L 0.9% NaCl with 1 g CaCl ₂ =4 L (153 mEq/L Na, 37.5 mEq/L HCO ₃ , 2.6 mmol/L Mg, and 2.25 mmol/L Ca)
SLED technical and logistic considerations	Dialysate flow rate (Q _D) 100–200 ml/min Blood flow rate (Q _B) 200 ml/min Treatment duration 8–12 h (evenings, using HD machines at night) Treatment delivered daily or alternate days depending on patient need ICU nurse monitors machine and records details of treatment like CRRT If no contraindications, systemic anticoagulation with unfractionated heparin to target activated partial thromboplastin time drawn peripherally to be 1.5 times control Dialysate jugs should last the entire treatment
PIRRT technical and logistic considerations	Effluent rate of 40–50 ml/kg per hour Treatment duration 8–12 h Treatment delivered daily or alternate days depending on patient need ICU nurse monitors machine and records details of treatment like CRRT Traditionally, anticoagulation not required but given the reports of the procoagulant nature of the COVID-19 syndrome, systemic anticoagulation with heparin may be necessary Replacement fluid and/or dialysate used should be precisely calculated to not waste fluid
HD, hemodialysis; CRRT, continuous RRT; SLED, sustained, low-efficiency dialysis; PIRRT, prolonged intermittent RRT; ICU, intensive care unit; QD, dialysate flow rate; QB, blood flow rate; D5W, 5% dextrose in water.	

become hypothermic with a longer extracorporeal circuit, so warming strategies may become imperative including warming CRRT fluids, integrated warming circuits, and bed-based warming tools. Telemonitoring could be considered for patients on HD to decrease the amount of time of that the dialysis nurse needs to spend inside the room. Encouraging social distancing while at work and dividing nurses into cohorts from a schedule standpoint can also help decrease the spread of COVID-19.

Dialysis Methods

HD machines and/or CRRT machines may become in short supply. In the setting of acute respiratory distress syndrome, many centers now employ extracorporeal membrane oxygenation (ECMO). CRRT in a patient on ECMO can be done by either using a CRRT machine in the traditional way (using a central venous catheter) or by adding an in-line hemofilter into the ECMO circuit if machines are not available. This method can be done without replacement fluid for ongoing ultrafiltration, or

replacement fluid can be added in to deliver continuous convective clearance (5). This method is more inaccurate than commercially available CRRT, and requires very close monitoring of intake and output volumes. However, to delay the need for dialytic clearance, you may opt to perform isolated ultrafiltration *via* the perfusionist running ECMO, rather than to utilize a HD machine.

For critically ill patients not on ECMO, continuous arteriovenous hemofiltration (CAVH) may be an option if CRRT machines are not available (6). CAVH requires central arterial and venous lines. The patient's own BP is used to pump blood from the large bore femoral artery through a hemofilter and back through a central venous line in the femoral vein. Ultrafiltration occurs due to hydrostatic pressures exceeding oncotic pressure in the filter and by a negative pressure occurring from gravity draining ultrafiltration away from the filter. Replacement fluid is infused either pre- or postfilter, and heparin is infused prefilter for anticoagulation. Meticulous records must be kept to avoid errors in fluid and electrolyte balance, and the patient will require close monitoring by

an ICU nurse. Different hemofilters may be needed to make the requisite luer-lock connections. Because experience is limited with CAVH, this would almost certainly be a last-resort option.

When any component of inpatient dialysis resources is low, urgent start peritoneal dialysis (PD) for AKI can be considered (7). Outcome data are limited, but acute PD appears to be as effective as other forms of RRT in the setting of AKI with no difference in mortality (8). Notable risks include pericatheter leaks, peritonitis, and unpredictable fluid removal rates. Tunneled flexible catheters are preferred to decrease the risk of pericatheter leak; however, catheters may still be lifesaving. PD catheters should be implanted based upon the method of expertise at the institution, but bedside placement could be reinstated by nephrologists in the setting of a crisis. We recognize that this practice has not been done in many decades and that many nephrologists lack the training to do it. Recent abdominal surgery is a relative contraindication due to the risk of hernia or leak at the healing incision site. Highly catabolic states also require special attention and may need an aggressive PD regimen to keep up with small-solute clearance.

The use of other machines to replace a standard dialysis machine may have merit such as machines that only do isolated ultrafiltration to perform all isolated ultrafiltration procedures, thereby keeping standard full-size dialysis machines available to perform treatments. In order to balance fluid removal needs and sufficient solute removal in critically ill patients, many novel strategies have been utilized along the spectrum of traditional intermittent HD and 24-hour CRRT. Of these, sustained, low-efficiency dialysis (SLED) and prolonged intermittent RRT are the two most easily rolled out emergently using available equipment. SLED uses standard machines, and lower dialysate and blood-flow rates over a longer time period (9). Prolonged intermittent RRT uses CRRT machines running at higher prescribed clearances for 8–12 hours before moving the machine to the next patient (10,11). Many centers will have both types of machine, so it is imperative to think broadly about available resources and how to use them in surge capacity. More lenient monitoring requirements by dialysis nurses can be implemented for SLED to maximize human resources.

As with any crisis, it is best to be prepared ahead of time. We cannot always predict when the next natural disaster or pandemic will occur, but we can have our inpatient dialysis units prepared. Preparation will afford all patients the best chance of a good outcome in a crisis, and will also decrease the anxiety and feelings of hopelessness that the staff caring for the patient may feel.

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