

# Acute Start Peritoneal Dialysis during the COVID-19 Pandemic: Outcomes and Experiences

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JASN 31: 1680–1682, 2020. doi: <https://doi.org/10.1681/ASN.2020050599>

Hospitalized patients with AKI rarely initiate peritoneal dialysis (PD) because of the limited availability of surgeons or interventionists with experience in placing PD catheters as well as of nephrologists and trained nursing staff who can manage and perform PD. Moreover, to minimize the incidence of mechanical complications, pericatheter leaks, and infection, the European Best Practice Guidelines for PD recommend not using PD catheters until 2 weeks after insertion,<sup>1</sup> which is not possible in the inpatient setting where there may be an urgent need for dialysis. The slow clearance of PD, a gentle form of RRT, also makes it impractical in these circumstances. As a result, patients with AKI usually undergo placement of a central venous catheter to start hemodialysis or continuous RRT (CRRT) instead.

This process runs smoothly under normal circumstances, when demand for RRT is not at the unprecedented levels experienced in New York City hospitals during the novel coronavirus disease 2019 (COVID-19) pandemic. However, because of such challenges as staffing issues, supply shortages, and dialysis circuit clotting during this health care crisis, many hospitals turned to acute PD to augment their RRT capacity.

At the Mount Sinai Hospital in New York City, as demand for RRT more than doubled during the COVID-19 pandemic, an acute PD program was swiftly planned and implemented. This article

describes the implementation process and this program's outcomes.

We inserted 21 PD catheters in 21 patients. Table 1 shows patient demographics and characteristics: mean age (62 years), sex (57% men), race (14% white, 52% black, and 33% Hispanic), mean weight and body mass index (BMI; 95 kg and 33 kg/m<sup>2</sup>), and comorbidities (diabetes mellitus, 12 patients [57%]; hypertension, 11 patients [52%]). Four had a history of abdominal surgery. At the time of catheter placement, 16 (76%) were receiving mechanical ventilation, with mean ventilator settings of tidal volume of 402 ml, respiratory rate of 29 breaths per minute, fraction of inspired oxygen of 53%, and positive end expiratory pressure of 7 cm H<sub>2</sub>O.

Patients with obesity are a high-risk group to treat for COVID-19.<sup>2</sup> Moreover, hypertension and diabetes mellitus are both known risk factors for poor outcomes in patients with COVID-19.<sup>3,4</sup> In addition, COVID-19 acute respiratory distress syndrome is associated with prolonged mechanical ventilation and a high short-term mortality.<sup>5</sup>

To the date of submission, nine (43%) of the patients have died. Of the 12 who remained alive, 3 (25%) had renal recovery, 2 (17%) were discharged on RRT, and 7 (58%) remained hospitalized on RRT. The high proportion of patients with risk factors helps explain why so many died during their hospitalization. There are some similarities in our

numbers to those reported in a case series of 30 patients from Brazil, in which 57% of 30 patients with AKI died and 23% had renal recovery, although only 7% remained on dialysis after 30 days.<sup>6</sup> It is important to note that the Brazilian patients were on high-volume PD, and the study took place before the COVID-19 pandemic, which may affect renal recovery rates.

Table 2 shows baseline laboratory data, both mean values from day 3 of PD onward and the difference between values on the day before initiating PD and the day of PD termination. The mean change in potassium was consistent with a decrease of 0.7 meq/L; serum bicarbonate increased by 2.1 meq/L, and serum albumin levels were unchanged. However, there was a greater decrease in BUN in the last day of treatment compared with the mean of day 3 onward (−15.3 versus −9.9 meq/L, respectively). Factors that may have blunted an otherwise even larger drop in BUN included incremental increases in average protein intake in both tube and oral feeds (as patients' BUN values decreased

Published online ahead of print. Publication date available at [www.jasn.org](http://www.jasn.org).

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**Table 1.** Demographics, baseline characteristics, and PD catheter outcomes

Characteristic	Outcome
Age, yr	62 (IQR, 53–67.5)
Men	12 (57%)
Race	
White	3 (14%)
Black	11 (52%)
Other (Latino)	7 (33%)
Weight, kg	95 (IQR, 79–114.5)
BMI, kg/m <sup>2</sup>	33 (IQR, 26.5–40.9)
Past medical history	
Diabetes mellitus	12 (57%)
Hypertension	11 (52%)
Abdominal surgery	4 (19%)
COVID-19 positive	20 (95%)
Ventilated	16 (76%)
Catheter insertion	
Surgery	16 (76%)
Interventional radiology	5 (24%)
Time to catheter use, h	
<6	2 (10%)
6–12	8 (38%)
12–24	11 (52%)
Complications	
Mechanical flow disruption	4 (19%)
Scrotal edema	3 (14%)
Pericatheter leak	2 (10%)
Peritonitis	1 (5%)
No complications	11 (52%)

IQR, interquartile range.

while on dialysis) and the initiation of intravenous methylprednisolone in three patients. Medical management largely maintained normoglycemia, although one patient who developed severe hyperglycemia on day 3 of PD was converted to a prescription of exclusively

**Table 2.** Laboratory data prior to and changes achieved while on PD

Serum Laboratory	Mean	Pre-PD – Post-PD <sup>a</sup>
Potassium, meq/L	4.7	–0.7
BUN, mg/dl	129.2	–15.3
Creatinine, mg/dl	8.2	–1.0
Bicarbonate, meq/L	19.4	2.1
Glucose, mg/dl	188	4.0
Albumin, g/dl	1.8	0.0

<sup>a</sup>The difference between values from the day prior to PD initiation to the day of PD termination.

icodextrin and had no further glycemic issues.

Prior to PD initiation, 12 patients required hemodialysis, continuous venovenous hemofiltration (CVVH), or both. Nineteen central venous catheters were placed for 21 hemodialysis and 6 CVVH treatments. Mean times on hemodialysis and CVVH were 1.9 and 57 hours, respectively. Mean blood flow rate was 251.2 ml/min. Nine hemodialysis treatments (43%) were terminated early because of hypotension or access clotting issues. Severe hypercoagulability is a well documented complication of COVID-19, with patients demonstrating markedly elevated fibrinogen and D-dimer plasma levels.<sup>7</sup> Only one patient required another form of RRT during time on PD. Acute PD provided an alternative form of RRT that bypassed the issue of hypercoagulability.

On average, six patients were on PD per day; mean PD duration was 8 days. For catheter placement, 76% were placed surgically at the bedside, and 24% were placed percutaneously in the interventional radiology suite. Eleven patients had no PD-related complications, and three developed scrotal edema. Four had mechanical flow disruptions; tidal PD may have helped remediate this issue in two patients, whereas the other two, both of whom had a past abdominal surgery, were unable to start PD. A limitation of bedside catheter placement is the inability to lyse intra-abdominal adhesions or perform an omentopexy, if needed. Despite the initiation of PD <24 hours after catheter placement in a cohort with a high BMI, only two patients had a pericatheter leak. One leak resolved after 48 hours with lowering of the fill volume to 0.75 L before gradually increasing it; the other developed on day 19 of PD treatment and resulted in treatment termination. One patient developed bacterial peritonitis, which responded to intraperitoneal antibiotics.

The average PD prescription was five exchanges: 1.5-L fills of 2.5% dextrose solution over 10 hours, with a last fill of 1.5 L of 7.5% icodextrin. The mean total cycle fill volume was 7049 ml; dwell

time was 86 minutes; drain time was 30 minutes; and the ultrafiltration rate was 405 ml/d, with a mean urine output of 622 ml/d. The average protein intake was 75.4 g/d.

We calculated weekly Kt/V values for eight patients from 16 urine and 17 dialysate samples, finding a mean total weekly Kt/V of 2.18, meeting the International Society for Peritoneal Dialysis recommendation of 2.10 Kt/V or greater.<sup>8</sup> The authors recognize, however, that urea clearance may be a sub-optimal marker for dialysis adequacy.<sup>9</sup> A comparison of hemodialysis needs before and during acute PD is in Supplemental Material, section 5.

The acute PD program successfully helped mitigate the demand for RRT during the COVID-19 pandemic's peak at Mount Sinai Hospital. It was a challenging process that required implementation of a treatment protocol, collaboration with interventional radiology and surgery for catheter placement, and hiring of additional nursing staff. We were able to provide our patients with this life-sustaining treatment and aid in their care. We hope that our experience demonstrates the feasibility of initiating an acute PD program during a health care crisis that results in increased demand for RRT.

## METHODS

From April 8, 2020 to April 26, 2020, we considered PD catheter placement for patients who required RRT and met one of the following criteria, regardless of their COVID-19 status, weight, BMI, or past medical history: AKI necessitating initiation of RRT; AKI already on RRT, with an expected prolonged hospital stay; or AKI on RRT with multiple dialysis circuit clotting issues. Prior abdominal surgery was not an absolute contraindication. Prone patients were excluded.

Patients on ventilators underwent bedside surgical catheter placement, whereas those who were on room air or oxygen supplementation *via* nasal cannula underwent percutaneous catheter

placement by interventional radiology (Supplemental Material, section 1). Of note, these procedures did not involve either a purse-string suture or a paramedian incision.

Initiation of PD occurred within 24 hours of catheter insertion. We used the HomeChoice cyclor and lactate-based PD solutions. We used low fill volumes (1 L) for the first treatment, with five to six exchanges over a 10-hour period, and we added heparin at a dose of 500 U/L to all peritoneal fluid bags. If there was no pericatheter leak, we gradually increased fill volumes to 1.5–2 L. All patients were prescribed an extended dwell of icodextrin to limit overnight troubleshooting.

PD nurses documented the exit site's condition, the PD effluent's appearance, the daily treatment total fill and drain volumes, initial drain volumes, average dwell and drain times, and total ultrafiltration achieved. We also obtained and recorded routine laboratory data and urine output, and we noted ventilator settings for patients requiring mechanical ventilation, protein intake from either tube feeds or regular oral intake, and steroid dosage delivered. Urine and PD effluent samples were collected, and urea clearance was calculated from April 17, 2020 onward (Supplemental Material, section 2).

We also documented the number of treatments, average blood flow rates, treatment durations, and the number of central venous catheters placements for patients who were on hemodialysis or CVVH prior to PD initiation as well as the number of dialysis treatments performed in the hospital in the 19 days prior to and during the acute PD program's duration.

A PD staff member was always present to troubleshoot any issues arising during the patients' treatments (Supplemental Material, section 3). Reasons for treatment termination included persistent peritonitis, mechanical flow disruptions, development of hernias or leaks, inadequate clearance and

ultrafiltration, and prone positioning. Discharge planning is described in Supplemental Material, section 4.

We used Microsoft Excel 16.30 for data collection and basic analysis. This project was approved by the institutional review board of the Mount Sinai School of Medicine (IRB-20–03479).

## ACKNOWLEDGMENTS

The authors acknowledge the hard work, dedication, and extraordinary efforts of the Mount Sinai Home Dialysis Unit PD nursing staff, without whom this project would not have been possible.

Dr. Osama El Shamy, Dr. Shuchita Sharma, and Dr. Jaime Uribarri designed the study; Dr. Mohamed Abdelbaset, Dr. Osama El Shamy, and Dr. Niralee Patel analyzed the data; Dr. Osama El Shamy made the tables; Dr. Linda Chenet, Dr. Noah Cohen, Dr. Osama El Shamy, Dr. David Lee, Dr. Robert Lookstein, Dr. Niralee Patel, Dr. Shuchita Sharma, Dr. Joji Tokita, and Dr. Jaime Uribarri drafted and revised the paper; and Dr. Mohamed Abdelbaset, Dr. Linda Chenet, Dr. Noah Cohen, Dr. Osama El Shamy, Dr. David Lee, Dr. Robert Lookstein, Dr. Niralee Patel, Dr. Shuchita Sharma, Dr. Joji Tokita, and Dr. Jaime Uribarri approved the final version of the manuscript.

## DISCLOSURES

All authors have nothing to disclose.

## FUNDING

None.

## SUPPLEMENTAL MATERIAL

This article contains the following supplemental material online at <http://jasn.asnjournals.org/lookup/suppl/doi:10.1681/ASN.2020050599/-/DCSupplemental>.

Supplemental Material. Catheter placement and use, total Kt/V calculation method, ancillary staff roles and cyclor troubleshooting, discharge planning, and hemodialysis demands before and during the acute peritoneal dialysis program.

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## **S1. Catheter Placement and Use**

All the surgical catheter placements were performed by the same two surgeons. All percutaneous catheter insertions were performed by the same two interventionists. None of the four proceduralists were involved in PD access placement for the maintenance PD program or prior expertise in PD access placement.

Prior to catheter insertion, patients would receive prophylactic antibiotic doses of either 1g Vancomycin or Cefepime intravenously, however since all of the patient who had catheters insertions were already prescribed those antibiotics, no prophylactic doses were needed.

### **Surgical PD catheter placement**

All patients were already intubated and received procedural sedation and neuromuscular paralysis. The patient's abdomen was prepped and draped in typical sterile fashion. A site in the right or left lower quadrant just lateral to the umbilicus was chosen for PD catheter insertion. It was then infiltrated with lidocaine 1% with epinephrine. A 3 cm horizontal incision was made with the scalpel and the subcutaneous tissue was divided with the electrocautery and scalpel. The anterior fascia was identified and divided sharply with the scalpel revealing the underlying rectus abdominis muscle. The rectus muscle fibers were split and the underlying posterior sheath was grasped, clamp, elevated and incised, entering the peritoneal cavity under direct vision.

A 57- or 62 cm curl cath, 2 cuff peritoneal dialysis catheter was threaded over a stylet introducer and introduced into the peritoneal cavity towards the pelvis. The catheter was advanced over the stylet introducer until the deep cuff was located superficial to the posterior sheath within the

rectus abdominis muscle. The anterior sheath was closed, securing the peritoneal dialysis catheter. The dialysis catheter was then tunneled subcutaneously, exiting through a stab incision, ensuring that the deep cuff was still located within the rectus abdominis muscle and the superficial cuff was located in the subcutaneous tunnel 2 cm from the exit site. The catheter was secured to the skin, the incision was closed in layers, and a dressing was placed.

Scarpa's fascia was re-approximated with 3-0 vicryl. A 4-0 monocryl subcuticular layer was then placed followed by LiquiBand. The catheter was then connected to the transfer set, and the locking adapter and cap were secured. The catheter was secured at the exit site with a nylon drain stitch.

### **Interventional Radiology Suite Catheter Placement**

The patient was placed supine on the fluoroscopic table and the abdomen was prepped and draped in sterile fashion. Ultrasound guidance included evaluation of potential access site in the mid abdomen. The site was anesthetized with lidocaine and a small dermatotomy was made with blunt dissection to the rectus fascia. Ultrasound visualization of needle entry into the peritoneum was then undertaken. A 0.018-inch wire was passed through the needle and fluoroscopically visualized to be intraperitoneal. The needle was then exchanged for a percutaneous access set and contrast injection performed to confirm intraperitoneal placement.

Using a combination of stiff guidewire and a Berenstein catheter, the guidewire was passed through the lower pelvis and up into the right or left upper quadrant (depending on side of catheter placement). The Berenstein catheter was exchanged for a peel-away sheath. The

peritoneal dialysis catheter was advanced over the wire through the peel-away sheath into the peritoneal cavity. The catheter was advanced until the deep cuff rested on the rectus fascia.

The exit site was marked approximately 5cm lateral to the access site, and was anesthetized with lidocaine. A small dermatotomy was created. The dialysis catheter was connected to a tunneling device and a subcutaneous tunnel was created. The dialysis catheter was pulled through the lateral exit site until the subcutaneous cuff was positioned within the subcutaneous tunnel.

Fluoroscopy confirmed the catheter tip to be curled in the lower abdomen. The catheter was flushed with 60mL of saline and 20mL were subsequently aspirated freely. The catheter was then capped. Finally, the access site was closed and sterile dressing applied at the access and exit sites.

## **S2. Total Kt/V calculation method**

To calculate the dialysate Kt/V, the concentration of BUN in each sample collected (in mg/dL) had to be corrected for the dilution factor. This was necessary since the automated PD cycler drains any excess volume in the peritoneal bags into the drain bag prior to starting the last fill. This calculation was made as follows:

$$\text{Dialysate BUN} = \frac{\text{Concentration of BUN (mg/dL)} \times (\text{IDV} + \text{TDV} + \text{Excess volume in PD bags})}{\text{IDV} + \text{TDV}}$$

(Where IDV = Initial drain volume, and TDV = Total drain volume)

In order to calculate the daily clearance, the following calculation was then undertaken:

$$\text{Daily Clearance} = \frac{\text{Dialysate BUN}}{\text{BUN}} \times \text{PD effluent volume (L)}$$

## Serum BUN

(Where the PD effluent volume is IDV + TDV)

The **weekly clearance** was then calculated by multiplying the daily clearance by 7.

Next, the patients' weight (kg) at the time of catheter insertion was obtained. If the patient's BMI was > 30, the adjusted body weight was calculated using the following formula:

$$\text{Adjusted body weight} = \text{Ideal body weight} + (0.25 \times \text{Actual body weight})$$

**Total body water** was then calculated by multiplying the adjusted body weight (for those who have a BMI > 30) or actual body weight (for those with a BMI ≤ 30) by 0.6 for men and 0.5 for women.

Finally, the weekly dialysate Kt/V was calculated as follows:

$$\text{Weekly Dialysate Kt/V} = \frac{\text{Weekly Clearance}}{\text{Total Body Water}}$$

Next, it was important to calculate the urine Kt/V. The first step is to calculate the urine daily clearance.

$$\text{Urine daily clearance} = \frac{\text{Urine BUN}}{\text{Serum BUN}} \times \text{Urine Volume (L)}$$

The urine weekly clearance was then calculated by multiplying the urine daily clearance by 7.

The urine weekly Kt/V was then calculated as follows:

$$\text{Urine weekly Kt/V} = \frac{\text{Urine Weekly Clearance}}{\text{Total Body Water}}$$

Finally, the total Kt/V was determined by adding the dialysate and urine Kt/V values calculated.

### **S3. Ancillary staff roles and cyclers troubleshooting**

To simplify matters for the nurses on the floor and in the ICU, who were overwhelmed with the patient load in the peak of the COVID-19 pandemic, each PD cart in the patients' rooms had a label on it with the contact information for the PD unit. If the cycler alarmed or any issues/concerns arose, they were instructed to contact the unit and a staff member would head over or instruct the nurse on how to proceed. Extra small caps were left on the carts in case patients needed to be disconnected – if they were going for a procedure or imaging study during their time on PD. The PD nurses noted down the expected treatment termination time and would round on the patients to confirm treatment completion.

In an ideal situation, we would have trained the floor nurses on troubleshooting the cycler, and how to aseptically connect and disconnect patients to the cyclers. The unit's contact information would still be supplied in order to support any unforeseen issues or concerns that arose.

### **S4. Discharge planning**

Patients who were COVID-positive who were being prepared for discharge and were deemed appropriate candidates for outpatient PD met with the chronic kidney disease educator and had a psychosocial evaluation performed by the home dialysis unit social worker. If the patient passed the evaluations and was interested in continuing PD in the outpatient setting, then they had a tunneled hemodialysis catheter placed, were transitioned to HD for 14 days post-discharge prior to returning to the home dialysis unit for training and initiation of outpatient PD. This policy was undertaken by the home dialysis unit to insure the safety of the home dialysis unit staff and decrease their exposure to COVID-19. Prior to their discharge from the hospital, the patients were instructed on how to maintain the PD catheter exit site dressing by the PD nurses.

On the other hand, those who were COVID-negative were transitioned to outpatient PD upon their discharge with no need to wait 14 days post-discharge.

#### **S5. HD demands before and during the AcPD program**

In the 19 days prior to AcPD initiation, a mean of 31 patients received HD per day: 9 COVID-positive (29%) – 6 of which were performed at the bedside. During the 19 days of the AcPD program, a mean of 34 patients underwent HD per day: 27 COVID-positive (79%) – 15 of which were performed at the bedside requiring 1:1 nursing. The average number of patients per day who had their treatments canceled or rescheduled went from 3 to 10.