Acute Peritoneal Dialysis During the COVID-19 Pandemic at Bellevue Hospital in New York City

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Abstract

Background The COVID-19 pandemic strained hospital resources in New York City, including those for providing dialysis. New York University Medical Center and affiliations, including New York City Health and Hospitals/Bellevue, developed a plan to offset the increased needs for KRT. We established acute peritoneal dialysis (PD) capability, as usual dialysis modalities were overwhelmed by COVID-19 AKI.

Methods Observational study of patients requiring KRT admitted to Bellevue Hospital during the COVID surge. Bellevue Hospital is one of the largest public hospitals in the United States, providing medical care to an underserved population. There were substantial staff, supplies, and equipment shortages. Adult patients admitted with AKI who required KRT were considered for PD. We rapidly established an acute PD program. A surgery team placed catheters at the bedside in the intensive care unit; a nephrology team delivered treatment. We provided an alternative to hemodialysis and continuous venovenous hemofiltration for treating patients in the intensive-care unit, demonstrating efficacy with outcomes comparable to standard care.

Results From April 8, 2020 to May 8, 2020, 39 catheters were placed into ten women and 29 men. By June 10, 39% of the patients started on PD recovered kidney function (average ages 56 years for men and 59.5 years for women); men and women who expired were an average 71.8 and 66.2 years old. No episodes of peritonitis were observed; there were nine incidents of minor leaking. Some patients were treated while ventilated in the prone position.

Conclusions Demand compelled us to utilize acute PD during the COVID-19 pandemic. Our experience is one of the largest recently reported in the United States of which we are aware. Acute PD provided lifesaving care to acutely ill patients when expanding current resources was impossible. Our experience may help other programs to avoid rationing dialysis treatments in health crises.

Introduction

The COVID-19 pandemic created an unprecedented strain on health care systems around the world. Early data from Wuhan, China (1–3), did not report the high rates of AKI that were subsequently seen in Italy and New York. The dramatic COVID surge in March 2020 in New York City threatened to overwhelm hospital capacity (4,5) for the provision of KRT. During early March 2020, New York City Health + Hospitals/Bellevue (BH) put together an action plan (Supplemental Material) to manage the anticipated increased needs for KRT; acute peritoneal dialysis (PD) was thought to be the best option to rapidly expand the capacity to provide KRT. By April 1, 2020, it became clear that our ability to handle the surge of patients with AKI using our current modalities, intermittent hemodialysis (IHD) and continuous venovenous hemofiltration (CVVH), was insufficient. Many hemodialysis nurses were unavailable due to COVID-related illness, resulting in a shortage of trained nurses. The intensive care unit (ICU) nursing staff that performs CVVH was overtaxed because of the expansion of ICU capacity mandated by New York State. Furthermore, CVVH machines were being used at full capacity and CVVH supplies were rationed by the supplier and being rapidly depleted.

In response, we promptly implemented the plan that had been conceived weeks before the surge. Under normal circumstances in Bellevue, acute PD had not been utilized for AKI for several decades. According to the International Society of Peritoneal Dialysis guidelines, the use of PD to treat patients with AKI is an

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acceptable form of treatment (6). Given the urgent nature of the circumstances, we felt the necessity to establish acute PD capability as our usual KRT modalities were being overwhelmed by COVID-19 AKI. Herein, we describe the rapid and successful implementation of an acute PD program during the COVID-19 pandemic in a period from mid-March to May 2020.

ICU Capabilities and Initial Challenges for KRT

Before the COVID-19 pandemic, BH had 66 ICU beds, ten ICU-capable beds in the emergency department (ED), and 780 total beds. The inpatient hemodialysis (HD) unit could accommodate 12 inpatients/d, 6 d per wk. Three portable HD machines and four CVVH machines were sufficient to provide bedside dialysis in both the ICU and non-ICU inpatients.

A total of 51 patients were seen by the Nephrology Service between January 20 and February 1, 2020; 26 were patients with ESKD who received dialysis in the inpatient unit, nine patients had ESKD who received bedside dialysis. A total of 11 patients in the ICU had AKI, five received bedside IHD, three received CVVH, and three did not require KRT. Typically, fewer than five patients per day received bedside KRT between the ICU and regular floors.

In response to the surge, 90 overflow ICU beds were established in ICUs, the ED, the endoscopy suite, and retrofitted old wards. At its peak on April 7, 2020, Bellevue had 134 ICU patients and 25 additional critical care patients in an overflow ICU area in the ED. Between March 10 and May 17, 2020, the nephrology service evaluated a total of 159 ICU patients with stage 2 or 3 AKI, most requiring KRT. This was not expected and was above the previously reported levels of COVID-19–associated AKI (4,5).

Additionally, the inpatient HD unit was closed for patients with COVID, necessitating bedside HD for all admitted patients as most patients without COVID were transferred to outside hospitals. During this time, we accommodated 35–40 inpatients requiring KRT per day, 15–20 of whom received bedside hemodialysis treatments (Figure 1).

The number of patients requiring KRT exceeded our baseline capacity for both IHD and CVVH. The challenges for providing IHD were (1) inadequate number of portable HD machines, (2) insufficient staffing due to illness and increased census, and (3) lack of adequate plumbing for water sources and usable drains in newly created ICU areas. Provision of CVVH was also severely limited for the same reasons.

We attempted to expand our KRT capabilities in several ways. Hemodialysis treatments were shortened, and the frequency decreased to less than three times per week for selected patients on the basis of their metabolic and volume requirements. Patients without COVID but with stable chronic HD were transferred to affiliated facilities. CVVH was expanded by performing two 10-hour accelerated venovenous hemofiltration treatments per machine in 24 hours, providing two patients with treatments each day (7,8). However, this strategy rapidly depleted CVVH disposable supplies (filters, tubing, dialysate bags, disposable bags) with no prospect of replenishment due to the nationwide rationing imposed by suppliers. Patients infected with COVID-19 also had an increased propensity to clot HD blood lines, as well as IHD and CVVH membranes and circuits, rendering these modalities useless in some patients and contributing to supply shortages. These patients experienced worsened anemia, further driving demand for blood products that were in short supply. We were facing the prospect of rationing dialysis resources.

To address these issues, we created an acute PD program. Initial planning took place in the weeks before the surge and took about 2 weeks to implement, with the first PD catheter placed on April 8, 2020. The acute PD program turned out to be instrumental in the BH response to COVID-associated AKI.

Materials and Methods
Planning

The use of acute PD to treat AKI requiring KRT was nonexistent before the COVID-19 pandemic at BH. Both
outpatient HD and PD were outsourced at BH and rarely were patients with chronic PD treated in the hospital. However, in anticipation of a greater need for KRT during the surge of patients with COVID-19, we put together an acute PD implementation protocol (Supplemental Material) in discussion with colleagues internally and from other institutions. The protocol described the roles and responsibilities of the staff, included supply lists, guidance for PD catheter placement, and links to online training resources for performing continuous ambulatory PD, automated PD, and percutaneous catheter placement.

Training of staff was a priority because there were few able to perform PD. We had to educate ICU doctors and nurses about acute PD in AKI and the equivalence of PD to peritoneal catheter placement, and links to online training resources for performing continuous ambulatory PD, automated PD, and percutaneous catheter placement.

Supply-Chain Issues
Before the surge, we accrued a list of PD supplies with the assistance of experienced PD nurses. We were able to find vendors who rapidly supplied us with solutions, transfer sets, drain bags, and PD catheters. We obtained about 100 catheters of different sizes to ensure sufficient capacity and to reduce the need to restock in the middle of the pandemic. With elective surgery suspended and operating supplies available, surgeons were able to assemble catheter insertion instrument trays. Personal protective equipment (PPE) was used according to BH infection control protocol for each patient contact, as is done for CVVH or HD or other procedures.

Surgical Support
A team of surgeons committed to providing support with insertion and management of PD catheters was an essential part of the plan. The lead surgeon (M.T.) at BH was responsible for finalizing the details of the insertion technique and acted as a point person for all procedures to increase efficiency. The team of surgeons was available around the clock, 7 days a week, allowing PD catheters to be placed typically within 12 hours of request by the nephrology team. The catheters were primarily inserted using a limited cut down to the peritoneal membrane through the rectus muscle at bedside in the ICU as all but one patient was intubated and sedated (13,14). Laparoscopic technique was not employed because of the potential aerosolization of COVID-19 particles (15).

Staffing, Staff Training, and Initial Experience
The major advantages of PD are its low-tech nature and relative ease for rapid training. This was critical given the constraints of trained nursing staff noted above. The initial PD team consisted of the lead nephrologist (N.C.), volunteer non-nephrology physicians (including pediatric ophthalmologists and dermatologist), and ambulatory care nurses. Initially, there were no PD nurses in the hospital available to assist. Subsequently, the team grew to include two volunteer PD nurses (day 9 of our effort), nurse practitioners, and physician assistants obtained through the Federal Emergency Management Agency. The team members from this agency who were PD nurses also assisted with hands-on training and supervision. The PD prescription was managed by the PD consult service that included nephrology attendings and renal fellows in consultation with the ICU team.

An experienced PD nurse from a private outpatient dialysis unit affiliated with BH and the lead nephrologist made training videos for manual PD and for automated PD. Lessons from the nephrologist and the “homemade” training videos were used to train the new PD team. Online resources from Fresenius and Baxter (Supplemental Material) were also utilized for additional detail but were not tailored for our acute PD needs. Team members were familiar with the main aspects of sterile procedures due to their medical background and were able to effectively learn the sterile procedures needed for PD. Overall, 25 people were on the PD team and we were able to provide exchanges 24 h/d by the end of the first week.

PD Prescription and Delivery
PD catheters were flushed and used immediately after insertion with low volume exchanges (500 ml) using continuous ambulatory PD bags with heparinized dialysate. The freshly inserted catheter was flushed three times with 500 ml of 1.5% dextrose dialysate solution or until clear if bloody. Heparin, 500 U/L, was added to dialysate to prevent fibrin formation. The initial exchange volume was 500 ml of 1.5% or 2.5% dextrose solution with a dwell time of 2 hours. In the absence of leaks, we increased exchange volume by 250 ml every 2–3 exchanges for the first six exchanges, then more rapidly until a volume of 2000 ml was reached, usually within the first 36 hours. In the event of leaks, dwell volume was reduced, or exchanges were held for 12 hours. The typical PD prescription was 5–8 exchanges/d, depending on dwell time, over 17 hours. As team members were added, we expanded PD exchanges to 24 hours and were able to achieve higher clearance using manual PD until cyclers were available. The typical exchange volume was 10–16 L/d when manual PD was used; exchange volume increased to 17–20 L/24-h period when cyclers were used. Adjustments to these prescriptions were made according to individual patient ultrafiltration and metabolic needs.

In mid-April, we acquired 18 automated cyclers, which greatly eased the workload of the PD team and enabled high-volume PD for better clearance (16,17). Patients who were functioning PD catheters and were in the supine position were subsequently placed on cyclers following our initial manual prescription to ensure the catheter was functioning well.

Patients in the prone position remained on PD using manual exchanges because occasionally flow was obstructed and was more easily adjusted with manual exchanges. Obstruction of flow occurred less frequently with more experience and better coordination with the proning team. In total, seven patients received PD while being placed in the prone position for 19 h/d, one of whom recovered to her baseline kidney function. The prescription was adjusted for these patients with manual exchanges every 1 hour while supine and every 2–3 hours while prone, with a maximum 1500 ml dwell while in the prone position. We were able to successfully perform adequate manual PD on patients who were prone with minimal complications by carefully coordinating with proning teams (16,17).
Patients were moved closer to the door, enabling the cyclers to be placed outside of the room (Figure 2), to minimize exposure of staff to COVID-19 infection and to lessen use of PPE.

Eligibility

The renal consult team was initially consulted by the ICU team to evaluate patients with AKI. All patients with COVID, who had rapidly rising creatinine, were severely oliguric, acidic, hypervolemic, hyperkalemic, or had uremic symptoms were considered for RRT.

A decision-making tree for choosing dialytic modality is shown in Figure 3. All patients who needed KRT in the ICU were eligible to receive PD catheters except for those in whom we anticipated technical challenges, usually because of prior abdominal surgery, severe obesity, or known varices. All the eligible patients with PD in the ICU were intubated, sedated, and on pressor support for hypotension. If patients were hyperkalemic (serum potassium concentration >6.5 mEq/L) despite medical therapy, such that rapid dialytic removal of potassium was necessary; CVVH treatments were started while simultaneously having a PD catheter placed if they had no contraindications. There were early concerns that respiratory status might be adversely affected by PD (17,18). This did not occur in our patients. We were able to successfully place PD catheters in patients with morbid obesity, up to a body mass index of 51 kg/m². Some patients who had been on CVVH and had no contraindications were transitioned to PD once the program was started if believed to require a prolonged hospitalization. ESKD patients in the ICU who were on CVVH because of hemodynamic instability were also considered for PD if a prolonged admission was anticipated. Additionally, because proning was not always planned, we did not consider it a contraindication (18).

In summary, enough PD catheters were placed to offset shortages in other modalities and allowed CVVH and hemodialysis to be done for those not suitable for PD, thereby meeting the needs of all AKI patients; all patients requiring KRT received it.

IRB Review

The study was approved by the institutional review board at New York University Langone Hospital (study i20-00809). This is a retrospective review and thus the requirement for informed consent was waived.

Results

Daily dialysis treatments, all modalities, between April 7 and May 8, 2020 ranged from 30 to 40 (Figure 1). As of May 8, 2020, 63 patients were evaluated for PD and 39 PD catheters were placed into ten women and 29 men. The average age was 59.5 years. Two patients had ESKD. Outcomes are summarized in Table 1. As of June 10, 2020, 39% of the AKI patients started on PD recovered adequate kidney function and dialysis was stopped. All patients continued on PD as long as needed or until they died. The average age of men and women who recovered renal function was 56 and 59.5 years, respectively, and for men and women who expired was 71.8 and 66.2 years, respectively. One ESKD patient who changed to PD because of vascular access complications was discharged on PD.

Of the 39 patients who had catheters placed, nine (23%) had transient leaks that were resolved with reduction of dwell volume. There were no cases of peritonitis (0%), tunnel infections, or exit site infections. Two catheters
(5%) needed surgical revision because of poor flow, and six (15%) catheters had minimal postplacement bleeding treated with Surgicel. One patient (2.5%) with a poorly functioning catheter required conversion to HD before recovery.

PD delivery in our patient population was monitored closely by the attending nephrologists. The patients were monitored for extracellular fluid volume overload and depletion, electrolyte and urea levels, and acid-base status to assess efficiency as with the other KRT modalities. The goal ultrafiltration (UF) volume was discussed with the ICU team and dialysate solution dextrose concentrations were adjusted accordingly. We were able to routinely achieve prescribed UF rates, removing up to 5 L in a 24-hour period, on par with other modalities. Of particular note, we used lower volume exchanges to avoid respiratory compromise (16,17). PD was tolerated by ventilated patients with hemodynamic instability and did not cause blood loss or systemic infections seen with the other modalities.

With this protocol and a large team of people who were able to perform many exchanges per day, we were able to maintain adequate clearance in the acute PD patients. Other than the one patient who switched to hemodialysis due to catheter malfunction, no PD patient required supplemental dialytic support with hemodialysis or CVVH.

**Discussion**

New York City was the epicenter for COVID-19 infections in the United States in mid-March until end of May 2020.

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**Table 1. Patient outcomes by gender and age**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients who received PD catheters</td>
<td>29</td>
<td>10</td>
<td>39</td>
</tr>
<tr>
<td>Recovered before starting PD</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>ESKD</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Recovered and had catheter removeda</td>
<td>9/27 (33%)</td>
<td>5/9 (56%)</td>
<td>14/36 (39%)</td>
</tr>
<tr>
<td>Expired on PD</td>
<td>20/28 (71%)</td>
<td>4/10 (40%)</td>
<td>24/38 (63%)</td>
</tr>
<tr>
<td>Average age of all patients (yr)</td>
<td>59.5</td>
<td>66.2</td>
<td>59.5</td>
</tr>
<tr>
<td>Average age, recovered patients (yr)</td>
<td>56</td>
<td>59.5</td>
<td>57.6</td>
</tr>
<tr>
<td>Average age, expired patients (yr)</td>
<td>71.8</td>
<td>62.3</td>
<td>60.6</td>
</tr>
</tbody>
</table>

*PD, peritoneal dialysis.

*ESKD patients are not included in this calculation.*
BH, the largest public hospital in New York City and the tertiary referral hospital for the Health and Hospitals Corporation network of New York City public hospitals, was particularly taxed. The number of COVID-associated AKI patients overwhelmed our typically used dialysis modalities, compelling us to start an acute PD program to provide adequate KRT. To our knowledge, our experience with acute PD at a single hospital is the largest reported during the pandemic and one of the largest case series of acute PD reported in the United States in recent years.

Acute PD as a modality to treat KRT has become underutilized. We summarize some of the limitations to the use of various modalities in Table 2. Several studies and meta-analyses show PD to be noninferior to IHD or CVVH (16,17). It also continues to be used widely in children (19–21). Nevertheless, there is a reluctance to use PD to treat adult patients in the ICU in the United States. The reasons for this underutilization may be a lack of familiarity with the technique by nephrologists, intensivists, and nursing staff, and the ease of ordering CVVH by the physicians. Unease about the certainty of UF and clearance potential and misconceptions regarding complications or effectiveness despite many positive trials also contribute (21). We observed a mortality rate of 63% for patients with stage 3 AKI receiving PD, comparable to or less than the mortality reported in other series of patients with COVID with stage 3 AKI, suggesting

Table 2. Limitations of different KRT modalities during the COVID-19 surge

<table>
<thead>
<tr>
<th>Resource</th>
<th>HD</th>
<th>CVVH</th>
<th>Acute PD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptance</td>
<td>Familiar, commonly used</td>
<td>Familiar, commonly used</td>
<td>Not used in Bellevue except rarely for chronic PD patients</td>
</tr>
<tr>
<td>Nursing staff</td>
<td>Limited trained dialysis nurses and many sick from COVID-19</td>
<td>ICU nurses trained in CVVH but ICU nurses overwhelmed with increased patient numbers</td>
<td>ICU nurses trained in PD, but rarely used. Required retraining effort when already overwhelmed</td>
</tr>
<tr>
<td>Non-nursing Staff</td>
<td>Difficult to train acutely</td>
<td>Difficult to train. Trained non-ICU nurses but needed significant oversight by the ICU nurses</td>
<td>Easier to train medical staff. Nephrologist-trained deployed MDs, PAs, and non-dialysis nurses</td>
</tr>
<tr>
<td>MD staffing</td>
<td>Adequate number of nephrologists to oversee</td>
<td>Adequate number of nephrologists and intensivists to oversee</td>
<td>Increased nephrology staff needed to implement the program. Surgeons available due to canceled elective cases</td>
</tr>
<tr>
<td>Nondisposable equipment</td>
<td>Fixed number of dialysis machines</td>
<td>Fixed number of CVVH machines</td>
<td>Not needed for manual PD, initially no cyclers, obtained 18 cyclers</td>
</tr>
<tr>
<td>Disposable equipment</td>
<td>Adequate supplies</td>
<td>Filters depleted by clotting and using machines for two people per d. Filters and fluid rationed by supplier</td>
<td>Percutaneous insertion kits not available. Used OR kits with open approach for placement. Initial supplier rationed PD supplies Ordered from alternative supplier</td>
</tr>
<tr>
<td>Disease-related limitations</td>
<td>Hemodynamic instability</td>
<td>Hypercoagulability with significant number of clotted filters</td>
<td>Hypermetabolic, prone positioning was used, laparoscopic placement avoided, ARDS on ventilator PD catheter placed at the bedside. Vascular access sepsis risk avoided, less blood loss, biocompatible, PD skills easier to learn. Gradual volume removal</td>
</tr>
<tr>
<td>Benefits</td>
<td>Easy placement of dialysis catheter</td>
<td>Easy placement of dialysis catheters</td>
<td></td>
</tr>
<tr>
<td>Potential risks</td>
<td>Sepsis, clotting, blood loss, hypotension, bioincompatible membrane</td>
<td>Sepsis, clotting, blood loss, hypocalcemia, alkalosis, potentially bioincompatible</td>
<td>Infection (peritonitis, tunnel infection), leak, inflow/outflow problems, hyperglycemia, bleeding at surgical site</td>
</tr>
<tr>
<td>Other issues</td>
<td>Requires plumbing in room</td>
<td>Not available in the ED overflow ICU</td>
<td>24 h before peritoneum primed for effective dialysis</td>
</tr>
</tbody>
</table>

HD, hemodialysis; CVVH, continuous venovenous hemofiltration; PD, peritoneal dialysis; ICU, intensive care units; MD, medical doctors; PA, physician assistant; OR, operating rooms; ARDS, acute respiratory distress syndrome; ED, emergency department.
we were able to deliver adequate therapy (5,22,23). Furthermore, we were able to achieve this with a negligible complication rate, which is a tribute to the skill of the surgical team and the scrupulous technique of the PD and nursing staff.

Our experience provides a roadmap for responses to future crises with heavy burdens of AKI. It demonstrates that the rapid development of PD capability is a viable alternative to reliance on expanding hemodialysis and CVVH capacity, and can be implemented in centers with minimal prior experience with PD. There are several advantages of this approach. We reduced our reliance on a single source of consumable supplies, a critical factor if future crises challenge typical supply chains in the same fashion as COVID-19. The simplicity of PD allows rapid training of traditional and nontraditional medical staff to deliver PD, which is not possible with more technically complex hemodialysis and CVVH options. The use of automated cyclers further simplified delivery and limited the number of patient contacts per day, thereby reducing provider risk compared to hemodialysis and CVVH and preserving PPE. Lastly, PD can be delivered manually and is not limited by the availability of dedicated machines, or electrical power.

Key elements required for successful implementation include organization of a multidisciplinary team including nephrology, surgical, and nursing, development of standard protocols, education of ICU staff, and a resource for rapid training. We believe that adoption of the steps outlined may be key to avoiding the need to ration KRT in future waves of COVID-19 or other health crises and should be considered for programs considering how to ensure adequate responses. We advocate that acute PD can and should be used in acutely ill patients. During times of shortages, it can be used to offset other modalities when expanding current resources is impossible.

Our experience demonstrates that establishing an acute PD program during a crisis is possible and can be lifesaving.

Disclosures
D. Charytan has consulted for Fresenius Medical Care and Medtronic, has received research support from Bioporto and Medtronic, and has received fees related to service on a trial committee from PLC Medical. D. Goldfarb has consulted for AstraZeneca. All remaining authors have nothing to disclose.

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None.

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Author Contributions
B. Dyal was responsible for the methodology; B. Gelb conceptualized the study; D. Bails was responsible for the resources; D.M. Charytan conceptualized the study, and was responsible for the methodology, resources, visualization, and the review and editing of the writing; D. Patel was responsible for the investigation and methodology; D.S. Goldfarb conceptualized the study, and was responsible for the review and editing of the writing; F. Ranjetha was responsible for the investigation; H. Chawla was responsible for the data curation and review and editing of the writing; J. Benstein conceptualized the study, and was responsible for the review and editing of the writing; J. Scherer was responsible for data curation, investigation, methodology, and the review and editing of the writing; L. Joseph was responsible for the investigation; M. Tandon was responsible for the investigation, methodology, and writing of the original draft; N.J. Caplin conceptualized the study, conducted the formal analysis, investigation, project administration, resources, supervision, and wrote the original draft; N. Thompson was responsible for data curation, methodology, and project administration; O. Zhdanova conceptualized the study, curated the data, conducted the investigation, and wrote the original draft; Q. Soomro was responsible for the investigation and methodology; R. Amerling was responsible for the investigation and the review and editing of the writing; S. Iyer was responsible for data curation and investigation.

Supplemental Material
This article contains the following supplemental material online at http://kidney360.asnjournals.org/lookup/suppl/doi:10.34067/KID.K360202000519/DCSupplemental.


Introduction
PD Candidates.
COVID-19 Concerns.
PD Protocol.
Procedure.
Common PD issues.
PD catheter placement.
PD training videos.
PD supplies.

References


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Supplemental Information for “Acute Peritoneal Dialysis During the COVID-19 Pandemic at Bellevue Hospital in New York City”

Guide for Acute Peritoneal Dialysis for Treatment of Renal Failure in COVID+ Patients
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Introduction:

The COVID-19 pandemic created an unprecedented strain on the U.S. health care system. Nowhere was this greater than in New York City, which became one of the global epicenters. The incidence of acute kidney injury (AKI) in severely ill hospitalized patients was about 40% at our institution. Conventional hemodialysis (HD) and continuous renal replacement therapies (CRRT) are resource and labor intensive, exacerbated by a higher than usual frequency of clotting, due to a hypercoagulable state.

Severe AKI with COVID-19 requiring urgent dialysis and an increasing number of chronic HD patients who miss their regularly scheduled dialysis sessions are anticipated to present to the emergency department for possible admission. We anticipated we would not be able to handle the increased demand during the peak surge of patients during the outbreak and decided to start an acute peritoneal dialysis program at Bellevue Hospital (BH).

Overall Objectives:
Initiate acute peritoneal dialysis (PD) in select patients to:

• Maintain RRT capacity
• Maintain a manageable number of patients and workload for HD nursing and ICU staff performing continuous venovenous hemofiltration (CVVH).

Utilize PD which will allow for rapid training of additional medical staff without dialysis expertise.

A major advantage of PD is the ease with which nursing and other staff can be trained. The procedure is not technically challenging but requires strict sterile technique. The learning curve to train staff to provide HD, CVVH, and AVVH is much steeper.

PD allows for an expanded pool of trained staff which can include nurses, PAs, technicians, and physicians.

Another advantage of PD is that the timing of exchanges can be varied to permit other nursing activities to minimize additional exposure and use of PPE.
Surgeons at NYU, Bellevue, and the Manhattan VA with expertise in PD catheter placement have committed to providing support with the placement of double cuff peritoneal dialysis catheters.

**Targeted patients for acute start inpatient PD:**

1) AKI patients in acute care or ICU beds with indications to initiate RRT and who meet criteria for PD catheter placement (see below).
2) COVID Neg->Stage 5 chronic kidney disease in need of RRT will be considered for PD.
3) Patients who have initiated HD or CVVH during the current admission for AKI, who do not have a contraindication for PD and are expected to have a prolonged hospital stay.
4) If HD demands outpace capacity, admitted ESKD patients on HD may be transitioned to PD.
   • ESKD/HD patients who are utilizing many resources i.e. additional UF sessions
   • All admitted patients may be considered, regardless of COVID-19 status, or whether they will be able to do PD as an outpatient.
   • PD candidates can have both HD/PD access upon DC with plan to transition to PD as outpatient to minimize chronic HD usage

**The proposed workflow:**

a) Inpatient renal teams to assess patients for criteria to initiate or transition to PD.
b) Identify these patients to the PD team (TBD at each hospital)
c) If approved by PD team, they will contact surgeon/interventional radiologist to insert the PD catheter – ideally within 24 hours of the request
d) Initiate exchanges immediately post-catheter placement using low volume (500ml) for the first 24 hours as per protocol.
e) if no peri-catheter leaks or other complications the volumes would gradually be increased to maximum 2000mL over 1-2 days.
f) Adjust prescription to control fluid overload, hyperkalemia and acidosis rather than to target a specific Kt/V
g) Exchanges will be performed when PD staff is available. Icodextrin can be used for overnight dwells if this is available to lessen the workload.

**PD Candidates:**
Patients will be considered suitable unless the following are present (exclusion criteria).
- Known varices
- Prior lower abdominal surgery (relative contraindication)
- Known abdominal adhesions
- Hyperkalemia >6.5 mEq/L refractory to medical management or with evidence of cardiac instability/arrhythmia

**COVID-19 Concerns:**
Critically ill COVID-19 patients are frequently ventilated with high FiO2 and PEEP settings. Theoretically, PD can raise intraabdominal pressure (IAP) and cause difficulty ventilating if there is too much pressure on the diaphragm.
- Consider monitoring bladder pressure while the patients are paralyzed and intubated to ensure no excessive IAP rise. Target <10-12mmHg.
The use of prone positioning is common in COVID-19 patients to try to improve oxygenation and although a theoretical contraindication, PD could be considered on a case by case basis if needed.

**PD Protocol:**
- Once PD candidate identified, initiate laxative to ensure adequate bowel movement: recommend lactulose, senna, colace, miralax as viable options.
• Dressing changes should be minimized during COVID-19 but performed when visibly soiled or leaking. An order should be placed for the application of gentamycin cream 0.1% or mupirocin cream 2% (or other antibiotic cream) to catheter exit site with each dressing change.
• Vancomycin 1 gram IV should be given peri-operatively
• Access to be inserted at bedside. Double cuffed PD catheter to be used. The catheter kit contains a plastic connector that should be placed by the surgeon. The transfer set should be attached before the sterile field is broken. If the catheter is not being used immediately, after checking for proper placement and flushing, instill 6000u (6ml of 1000u/ml heparin) into the transfer set, then disconnect bags and tubing.
• Cover with a NEW cap. NEVER REUSE MINICAPS or STAY SAFE Caps
• Low volume PD should begin immediately after catheter placement, unless advised otherwise by surgeon.
• Once access is obtained (before sterile field is broken) catheter is to be flushed with 1.5 or 2.5% dextrose solution with Heparin 500U/L added (1000u total for a 2L bag). The flush volume infused is 500mL and immediately drained. We repeat this for the entire 2000mL bag: 4 infusions, 3 drainages. The final 500cc is left in the peritoneum for 2 hours and then drained and continue exchanges as per the protocol.
• If patient has severe hypertension or volume overload, call nephrologist for high dose oral/IV diuretic and 4.25% dialysate.
• About 48 hours after catheter insertion, titrate up to 2000mL dwells q2h-3h.
• Of note, as exchange frequency increases, the frequency of connections and disconnections will necessitate additional bedside contacts. If the extension line is obtainable (see below, Baxter only) it can be used to reduce direct patient contact

PD Nursing Instructions for PD during COVID:
• All PD assessments and exchanges can be rescheduled and timed with existing nursing activities if exchanges to be done by the nursing staff.
• Exchanges are to be performed in supine position unless the patient is to be placed in the prone position and then use the prone protocol.
• If patient has a cough, we recommend cough suppressant.

Manual Peritoneal Dialysis Protocol
Equipment needed
• Hanging scale
• Dialysate fluid bag-% as per nephrologist
• Clamp (or tape)
• Appropriate PPE (goggles/face shield, gown, mask, gloves)
• Heparin
• Sanitizing solution (Alcohol, Chlorhexidine, Iodine etc.)
• Iodine cap

Background
There are 3 settings for manual peritoneal dialysis using the Fresenius ‘stay safe’ organizer: Drain (position 1), Flush (position 2) and Fill (position 3). The dial on the stay-safe disc makes it easy to visualize which position you are in.
**Procedure**

1. Prep bag
   a. Open packaging
   b. Wash hands/don gloves
   c. Clean med port of the dialysate bag with sanitizing solution. Remove the heparin cap and sterilize the top. Sterilize the port on the PD fluid bag with sanitizing solution.
   d. Inject appropriate amount of Heparin into dialysate bag after sterilizing the med port with sterilizing solution (alcohol can be used) (dose: 500 units of Heparin per 1 Liter of dialysate fluid)
   e. Remove cap from front of dial/bag
   f. Turn dial into drain position (if using Fresenius products)
   g. Break cone on bag

2. Stage area for peritoneal dialysis
   a. Don appropriate PPE
   b. Gather supplies needed (dialysate, scale, clamping device)
   c. Enter room 3. Initial prescription:
      a. If newly placed catheter then flush with 1.5% (or available %) 500mL x3 with draining between flushes (can flush more if needed to clear up blood)
      b. Start 500mL dwells with 2-3-hour dwell time for 3 dwells. (don’t worry if some fluid gets resorbed the first 24 hours because this is expected)
      c. If no leaking and tolerates can increase to 750mL x 1-2 dwells and then 1000mL for 2 dwells, then 1500mL for 2 dwells then 2000mL (full volume)
      d. Start regular manual PD with prescription based on metabolic needs and staff availability to perform exchanges.

4. Initiate set up
a. Hang scale on IV pole above patient
   i. Make sure it is set at zero
b. Hang dialysate fluid bag onto scale and affirm accurate weight
c. Slowly peel drain bag from dialysate bag and place on the floor beside patient bed, taking care not to step on said bag
d. ALWAYS MAKE SURE PATIENT’s CLAMP IS CLOSED PRIOR TO ATTACHMENT
e. Aseptically attach patient line to patient connector on dialysis bag, taking care to keep both ports clean
f. Set dial to position 2 and watch for approximately 2 seconds until you see bubbles created by fluid coming through flush line
g. Immediately set dial to position 3 and unclamp patient line
h. Watch scale to make sure appropriate volume is instilled for the dwell (If using < than the total contents can use the scale to determine the desired dwell volume.
i. Once appropriate volume has instilled
   i. Clamp patient line
   ii. Clamp upper dialysate line (with clamp or tape)
   iii. Set dial back to position 1  iv. Make note of the time, this is your dwell start time
   v. Remove PPE and dispose of
   vi. Document start time, prescription, and volume of dwell

5. Drain
   b. After dwell time is completed, Don PPE and prepare to re-enter room
c. Open clamp on patient end of line
   i. You will note the drain bag on the floor begin to fill with fluid (check for clarity).
   ii. Allow 20 minutes for fluid to collect in drain bag
   iii. Remove PPE and dispose properly
d. After draining for approximately 20 minutes
   i. Clamp patient line
   ii. Note color of drained fluid
   iii. Hang drain bag onto scale and assess the amount of fluid collected
   iv. Record drain time, color of fluid, and volume output
e. Aseptically initiate next dwell as before or apply Iodine cap and infuse heparin if additional dwell is not needed
f. Clamp all lines before disposal to prevent leaks
g. Dispose of peritoneal effluent as per hospital infection control protocols

**Common PD issues:**

**Slow drain or fill of dialysate**
- Attempt to reposition patient (sometimes a patient will drain better when leaning more to one side)
- Determine no pericatheter leak
- Gently press on patient’s abdomen while trying to fill/drain
- Attempt to flush line with 50 mL sterile syringe of saline 1-3 times
- Ask nurse if patient has had bowel movement in the past 24 hours ○ Constipation can prevent adequate draining in PD patient. Implement increased bowel regimen as needed
- Check an Abdominal film for PD catheter placement, Constipation or other unanticipated complications
- Can try tPA for possible fibrin clot at this point as per protocol

**Blood in the PD fluid**
- Flush with 1.5% 500mLx3 or until the fluid clears, if does not clear consult surgery

**Cloudy PD fluid**
- Send the fluid for culture and cell count
- Start antibiotics prophylactically until the culture is available and then can customize treatment based on organism and sensitivities
PD catheter leak
- Check the integrity of the catheter for damage
- Decrease the dwell volume to 500mL and proceed with manual exchanges. If no acute metabolic needs can hold PD exchanges for 12-24 hours and then resume PD starting at low volume. If holding PD temporarily, place heparin 6000u/6mL in the transfer set as per protocol. Cap to close the transfer set.
- Place a new dressing as per the protocol

tPA Protocol
- instill 8cc of 1mg/cc (8mg total) into the transfer set/PD catheter (total volume of the catheter and transfer set usually 6-7cc)
- let dwell in the catheter for 60 min
- try to flush with 50cc NS. If good flow can attempt a regular infusion and dwell. If still not good flow can repeat X1.
- If still poor flow consult surgery

ADDING MEDICATION TO THE PD FLUID
- When adding anything soak the med port of the solution bag for 3 min with alcavis or other sterilizing fluid (alcohol can be used)
- When adding any medication soak the top of the bottle with sterilizing solution for 3 min and always change the needle and always use a clean needle before adding the heparin (or other medication) to the fluid

Record Keeping:
Document:
- Time of the exchange,
- Fill volume,
- Drain volume (can be weighed with the scale or estimated), and
- Effluent appearance (cloudy, clear)
- Exit site

Solution Strength:
Peritoneal dialysis solution comes in three strengths, which are color coded:
A) Yellow or 1.5%--This solution has a low glucose concentration and will lead to little or no ultrafiltration (fluid removal). The effluent drain volume may in fact be smaller than the fill volume
B) Green or 2.5%--This solution contains a medium concentration of glucose and in most patients will lead to ultrafiltration (fluid removal).
C) Red or 4.25%--This solution will lead to the greatest amount of ultrafiltration (fluid removal). D) Icodextran--Used for overnight dwells (8-16 hours) (Baxter only)

The nephrologist will change the solution strength depending upon the patient’s hemodynamic status and fluid volume status.

Exit Site Care
- Clean exit site with normal saline. Tegaderm over exit site
- Administration of gentamycin cream 0.1% or mupirocin cream 2% to the exit site whenever the dressing is changed
- Avoid ointments as these may break down the polyurethane in the catheters.
Fresenius Stay Safe 1.5% Dextrose solution with tubing and drain bag

Fresenius transfer sets

Stay safe caps (Fresenius)
**PD CATHETER PLACEMENT**
Bedside technique description: From PD Surgeon Dr. Cheguevara Afaneh; other surgeons can use it potentially and it obviates the need for fluoroscopy

1. A right upper quadrant incision is made 3 cm lateral to the midline.
2. The subcutaneous tissue is dissected away from the anterior rectus sheath using monopolar energy and retractors.
3. Once the anterior rectus sheath is clearly exposed and clear of any subcutaneous tissue, it is sharply incised.
4. The muscle is then bluntly dissected away until the posterior rectus sheath is identified.
5. Two tonsil clamps are used to pull the posterior rectus sheath superiorly and away from the bowel. To avoid inadvertently grabbing the bowel, clamp the posterior rectus sheath on each side, then unclamp each clamp sequentially and re-clamping.
6. Sharply incise the posterior rectus sheath. A window into the peritoneal cavity is now achieved.
7. Advanced the dilator/sheath under direct visualization while pulling up on the clamps to create a potential space into the peritoneum. A 2-0 vicryl U-stitch is placed but not tied around the dilator/sheath.
8. Next, the dilator is withdrawn, and the sheath remains in place.
9. A 62.5 cm swan neck curl right-sided peritoneal dialysis catheter is introduced through the sheath after soaking it in heparinized saline and expelling all the air from the cuffs.
10. The sheath is snapped and withdrawn as the dialysis catheter is introduced. Care is taken to ensure the anterior line remained in the orientation as the catheter is advanced into the peritoneal cavity.
11. Once the sheath is fully withdrawn, the distal cuff is advanced into the rectus muscle.
12. The cuff is then secured to the posterior fascia by tying the 2-0 vicryl U stitch. This creates a tight seal and allows for initiation of emergent PD.
13. The anterior fascia is closed with 2-0 vicryl suture, taking care not to kink the tubing, allowing a window for the catheter to exit the anterior sheath. The catheter should be flushed at various points to ensure there is no kinking of the tubing with heparinized saline both before and after the catheter is tunneled.

Tunneling the cuff
1. The catheter dimensions and exit sites are measured.
2. A <1 cm exit site is made approximately 3-4 cm inferior and lateral to the introducer site.
3. The proximal end of the catheter is attached to the tunneler.
4. A subcutaneous tunnel is fashioned, and the catheter withdrawn through the exit site.
5. The tubing is separated from the tunneler. The cuff should clearly be 1-2 cm proximal to the exit site.
6. The connector is attached to the end of the PD catheter (usually included in the catheter set)
7. The transfer set (usually either Fresenius or Baxter) is attached before the sterile field is broken, and catheter should be flushed to assure flow because kinking under the skin can happen when it is tunneled.
8. ap if not being used immediately.
9. The introducer site is closed with deep dermal sutures with 3-0 vicryl. The skin is closed with 4-0 suture.

- Once access obtained recommend catheter to be flushed with peritoneal dialysis fluid 2L 1.5% or 2.5% dextrose solution with 500U/L (1000u total) Heparin added. The flush is 500cc infused and immediately drained. We repeat this for the entire 1500 or 2000cc bag. Can Start dwells at this time or hold overnight.
- Alternatively, after checking for proper placement and flushes, instill 6000u (6ml of 1000u/ml heparin) into the transfer set if not being used immediately otherwise after the solution is allowed to run in.

PD training videos
3. https://urldefense.proofpoint.com/v2/url?u=http-3A__players.brightcove.net_1992769035001_default-5Fdefault_index.html-3FvideoId-3D6032170902001&d=DwIFAg&c=j5oPp00eBH1io48DtsedeElZfc04rx3ExJHeIIZuCs&r=Ue7cNPZQiF Hsiq6_gBp8xGtSPqKXiv_AY8eJLmMH4&m=liTKvGk0ijMJETAHrkYf51edA1EVeoyQsQtn4vT NsLM&s=fsSlZ00NR1v6e3icGGHTKY1cx074ExOXC0X6a99bAyg&uc
4. https://www.youtube.com/watch?v=FDbo_e2oAM
PD supplies for each site assuming 10-15 pts per site with product order numbers:

PD fluid (Dianeal/Extraneal (Baxter) or Stay Safe (Fresenius)) - the 2L low volume bags to start
Approximately 45-60 bags per patient for 2-week time period. Assuming 15 patients 15 days X 15 patients = 900 bags of solution. We recommend 2L bags. (need to adjust below numbers based on the anticipated needs at your institution)

- Dianeal (Baxter) 2L Boxes (6/box)
  - 1.5% Dextrose (5B9766)
  - 2.5% Dextrose (5B9876)
  - 4.5% Dextrose (5B9796)
  - Extraneal (Baxter)-For overnight dwells (8-16 hours) 1 bag per night per patient
  - 30 boxes of 2L (6 per box) (5B4986)
  - Stay Safe Fluid (Fresenius) 2L bags (5 per box)
    - 1.5% Dextrose (054-20221)
    - 2.5% Dextrose (054-20222)
    - 4.25% Dextrose (045-20224)

Ultraclamps (Baxter) (12/Box) or any tubing clamps (can buy on amazon)-use 2 per exchange per patient. Can wash and reuse
  - 20 boxes (5C4957)

Minicaps (Baxter) (60/box) or Stay Safe Cap (Fresenius)(40 per box)
  - 60 Boxes (5C4466P)-Baxter
  - 80 Boxes (050-95012)-Fresenius

Spring Scale-recommend one per patient is best but, in a pinch, can share (or estimate). Also, can buy similar on Amazon
  - 20 scales (5K3582)-Baxter
  - Ohaus Spring Scale (36-8008-9)-Fresenius

Alcavis 50 (500ml/bottle) (Baxter) or ExSept (Fresenius)
  - 20 Bottles (5K4005)-Baxter
  - 20 Bottles (15117)-Fresenius

Transparent Dressings (50 per box) (Tegaderm or similar)
  - 5 Boxes (5K7579M)-Baxter

Transfer Set:
FMCNA Stay Safe Set 18 inch (050-95005)-start with 30 (one per patient needed) (Fresenius)
Minicap extended life PD Transfer set 6” (6/box) (5C4482) This is a change to the twist clamp and need extra so new product # (Baxter)
  - 10 boxes (need extra transfer sets if using extension tubing)

Stay Safe Organizer (Fresenius)-one needed per patient (030-10807)- Makes it easier to use the stay safe bags but not essential. There is a holder too that connects to the IV poles, but I would not recommend as might risk the PD catheters getting inadvertently pulled out if the pole is moved.
  - Would start with 30 organizers (Fresenius)

Warming Device (5K3961) or heating pad or warmer used for CVVH solution can be used to warm PD fluid (not essential)
  - 15 warming devices

Sterile drain extension line, 12 feet (5C4464P)-Baxter only. For use if putting the fluid outside the room
  - 30 drain lines
  - 30 drain sets (026-20226, 10/box – Fresenius)
Catheter Placement: 15/each
Catheters: PD catheter kit: Merit VPL 511
Marcaine or lidocaine (what % is typically stocked and used)
OR basic tray or DPL kit
Scalpels: #5, #10, #11 Blades
1L NS for infusion to check placement needed at the time of placement
Sutures: 3-0 vicryl
4.0 monocryl
3-0 nylon
Transfer set (connection that stays on attached to the catheter)
Heparin 6ml (1000u/ml) to be infused by the surgeon and left to dwell in the catheter (including the transfer set) if not used immediately

Merit Supplies
1. Catheters: recommend the classic catheters. They come in three sizes. The difference is the length and distance between cuffs. Should get 15-20 to start
   • Classic adult small-3 catheters (CF5250)-Or avoid, can primarily use standard size.
   • Classic adult standard-12 catheters (CF5260)
   • Classic adult large-5 catheters (CF5270)
2. VP-511 PD implantation system 15-20 kits-one per patient needed (can be substituted with OR kits if not available)
3. Repair kit (CE-1400)-I think should have 2 in case the cap or connector is damaged
4. Faller Trochar (FT1100)-apparently helps with difficult patients. 3 (not essential but can be helpful)
5. Fluid administration kit-used to flush post implantation. (K08-02385) (not essential)

The clinical educator from Merit: Jacquie Logue 801-712-1321
A 12-foot cycler standard drain line extension (life hack) can extend from usual PD catheter transfer set by 12 feet (Baxter only). A second transfer set is attached at the end of the extension. All CAPD modalities can be performed either outside of the patient room or at a distance that is consistent with COVID-19 distancing recommendations. Multiple extenders can fit together so it can be even 24 ft.

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Percutaneous Catheter Implantation

VP-511 PERCUTANEOUS IMPLANTATION SYSTEM
With Antegrade Catheter Faller Trocar

FT-1100 Metal Faller Trocar

Suggested for Ultrasound Guided Access and Fluoroscopic Placement

- VP511 Implantation System
- PD Catheter Kit
- CC-2300 Titanium Catheter Connector
- (Optional) MAX-HV™ Introducer System
- (Optional) Mentor Laureate® Hydrophilic Guide Wire
Supplemental Information for “Acute Peritoneal Dialysis During the COVID-19 Pandemic at Bellevue Hospital in New York City”

Guide for Acute Peritoneal Dialysis for Treatment of Renal Failure in COVID+ Patients
Compiled and written by Nina Caplin, M.D. and David Charytan, M.D. NYU Langone Medical Center
Nina.Caplin@nyulangone.org

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Introduction:
The COVID-19 pandemic created an unprecedented strain on the U.S. health care system. Nowhere was this greater than in New York City, which became one of the global epicenters. The incidence of acute kidney injury (AKI) in severely ill hospitalized patients was about 40% at our institution. Conventional hemodialysis (HD) and continuous renal replacement therapies (CRRT) are resource and labor intensive, exacerbated by a higher than usual frequency of clotting, due to a hypercoagulable state.

Severe AKI with COVID-19 requiring urgent dialysis and an increasing number of chronic HD patients who miss their regularly scheduled dialysis sessions are anticipated to present to the emergency department for possible admission. We anticipated we would not be able to handle the increased demand during the peak surge of patients during the outbreak and decided to start an acute peritoneal dialysis program at Bellevue Hospital (BH).

Overall Objectives:
Initiate acute peritoneal dialysis (PD) in select patients to:
• Maintain RRT capacity
• Maintain a manageable number of patients and workload for HD nursing and ICU staff performing continuous venovenous hemofiltration (CVVH).

Utilize PD which will allow for rapid training of additional medical staff without dialysis expertise.

A major advantage of PD is the ease with which nursing and other staff can be trained. The procedure is not technically challenging but requires strict sterile technique. The learning curve to train staff to provide HD, CVVH, and AVVH is much steeper. PD allows for an expanded pool of trained staff which can include nurses, PAs, technicians, and physicians.

Another advantage of PD is that the timing of exchanges can be varied to permit other nursing activities to minimize additional exposure and use of PPE.
Surgeons at NYU, Bellevue, and the Manhattan VA with expertise in PD catheter placement have committed to providing support with the placement of double cuff peritoneal dialysis catheters.

Targeted patients for acute start inpatient PD:

1) AKI patients in acute care or ICU beds with indications to initiate RRT and who meet criteria for PD catheter placement (see below).
2) COVID Neg->Stage 5 chronic kidney disease in need of RRT will be considered for PD.
3) Patients who have initiated HD or CVVH during the current admission for AKI, who do not have a contraindication for PD and are expected to have a prolonged hospital stay.
4) If HD demands outpace capacity, admitted ESKD patients on HD may be transitioned to PD.
   • ESKD/HD patients who are utilizing many resources i.e. additional UF sessions
   • All admitted patients may be considered, regardless of COVID-19 status, or whether they will be able to do PD as an outpatient.
   • PD candidates can have both HD/PD access upon DC with plan to transition to PD as outpatient to minimize chronic HD usage

The proposed workflow:

a) Inpatient renal teams to assess patients for criteria to initiate or transition to PD.
b) Identify these patients to the PD team (TBD at each hospital)
c) If approved by PD team, they will contact surgeon/interventional radiologist to insert the PD catheter – ideally within 24 hours of the request
d) Initiate exchanges immediately post-catheter placement using low volume (500ml) for the first 24 hours as per protocol.
e) if no peri-catheter leaks or other complications the volumes would gradually be increased to maximum 2000mL over 1-2 days.
f) Adjust prescription to control fluid overload, hyperkalemia and acidosis rather than to target a specific Kt/V
g) Exchanges will be performed when PD staff is available. Icodextrin can be used for overnight dwells if this is available to lessen the workload.

PD Candidates:
Patients will be considered suitable unless the following are present (exclusion criteria).
   • Known varices
   • Prior lower abdominal surgery (relative contraindication)
   • Known abdominal adhesions
   • Hyperkalemia >6.5 mEq/L refractory to medical management or with evidence of cardiac instability/arrhythmia

COVID-19 Concerns:
Critically ill COVID-19 patients are frequently ventilated with high FiO2 and PEEP settings.
Theoretically, PD can raise intraabdominal pressure (IAP) and cause difficulty ventilating if there is too much pressure on the diaphragm.
   • Consider monitoring bladder pressure while the patients are paralyzed and intubated to ensure no excessive IAP rise. Target <10-12mmHg.
The use of prone positioning is common in COVID-19 patients to try to improve oxygenation and although a theoretical contraindication, PD could be considered on a case by case basis if needed.

PD Protocol:
   • Once PD candidate identified, initiate laxative to ensure adequate bowel movement: recommend lactulose, senna, colace, miralax as viable options.
• Dressing changes should be minimized during COVID-19 but performed when visibly soiled or leaking. An order should be placed for the application of gentamycin cream 0.1% or mupirocin cream 2% (or other antibiotic cream) to catheter exit site with each dressing change.

• Vancomycin 1 gram IV should be given peri-operatively

• Access to be inserted at bedside. Double cuffed PD catheter to be used. The catheter kit contains a plastic connector that should be placed by the surgeon. The transfer set should be attached before the sterile field is broken. If the catheter is not being used immediately, after checking for proper placement and flushing, instill 6000u (6ml of 1000u/ml heparin) into the transfer set, then disconnect bags and tubing.

• Cover with a NEW cap. NEVER REUSE MINICAPS or STAY SAFE Caps

• Low volume PD should begin immediately after catheter placement, unless advised otherwise by surgeon.

• Once access is obtained (before sterile field is broken) catheter is to be flushed with 1.5 or 2.5% dextrose solution with Heparin 500U/L added (1000u total for a 2L bag). The flush volume infused is 500mL and immediately drained. We repeat this for the entire 2000mL bag: 4 infusions, 3 drainages. The final 500cc is left in the peritoneum for 2 hours and then drained and continue exchanges as per the protocol.

• If patient has severe hypertension or volume overload, call nephrologist for high dose oral/IV diuretic and 4.25% dialysate.

• About 48 hours after catheter insertion, titrate up to 2000mL dwells q2h-3h.

• Of note, as exchange frequency increases, the frequency of connections and disconnections will necessitate additional bedside contacts. If the extension line is obtainable (see below, Baxter only) it can be used to reduce direct patient contact

PD Nursing Instructions for PD during COVID:

• All PD assessments and exchanges can be rescheduled and timed with existing nursing activities if exchanges to be done by the nursing staff.

• Exchanges are to be performed in supine position unless the patient is to be placed in the prone position and then use the prone protocol.

• If patient has a cough, we recommend cough suppressant.

Manual Peritoneal Dialysis Protocol

Equipment needed

• Hanging scale

• Dialysate fluid bag-% as per nephrologist

• Clamp (or tape)

• Appropriate PPE (goggles/face shield, gown, mask, gloves)

• Heparin

• Sanitizing solution (Alcohol, Chlorhexidine, Iodine etc.)

• Iodine cap

Background

There are 3 settings for manual peritoneal dialysis using the Fresenius ‘stay safe’ organizer: Drain (position 1), Flush (position 2) and Fill (position 3). The dial on the stay-safe disc makes it easy to visualize which position you are in.
Procedure

1. Prep bag
   a. Open packaging
   b. Wash hands/don gloves
   c. Clean med port of the dialysate bag with sanitizing solution. Remove the heparin cap and sterilize the top. Sterilize the port on the PD fluid bag with sanitizing solution.
   d. Inject appropriate amount of Heparin into dialysate bag after sterilizing the med port with sterilizing solution (alcohol can be used)
      (dose: 500 units of Heparin per 1 Liter of dialysate fluid)
   e. Remove cap from front of dial/bag
   f. Turn dial into drain position (if using Fresenius products)
   g. Break cone on bag

2. Stage area for peritoneal dialysis
   a. Don appropriate PPE
   b. Gather supplies needed (dialysate, scale, clamping device)
   c. Enter room 3. Initial prescription:
      a. If newly placed catheter then flush with 1.5% (or available %) 500mL x3 with draining between flushes (can flush more if needed to clear up blood)
      b. Start 500mL dwells with 2-3-hour dwell time for 3 dwells. (don’t worry if some fluid gets resorbed the first 24 hours because this is expected)
      c. If no leaking and tolerates can increase to 750mL x 1-2 dwells and then 1000mL for 2 dwells, then 1500mL for 2 dwells then 2000mL (full volume)
      d. Start regular manual PD with prescription based on metabolic needs and staff availability to perform exchanges.

4. Initiate set up
a. Hang scale on IV pole above patient
   i. Make sure it is set at zero
b. Hang dialysate fluid bag onto scale and affirm accurate weight
c. Slowly peel drain bag from dialysate bag and place on the floor beside patient bed, taking care not to step on said bag
d. ALWAYS MAKE SURE PATIENT’s CLAMP IS CLOSED PRIOR TO ATTACHMENT
e. Aseptically attach patient line to patient connector on dialysis bag, taking care to keep both ports clean
f. Set dial to position 2 and watch for approximately 2 seconds until you see bubbles created by fluid coming through flush line
g. Immediately set dial to position 3 and unclamp patient line
h. Watch scale to make sure appropriate volume is instilled for the dwell (If using <than the total contents can use the scale to determine the desired dwell volume.
i. Once appropriate volume has instilled
   i. Clamp patient line
   ii. Clamp upper dialysate line (with clamp or tape)
   iii. Set dial back to position 1 iv. Make note of the time, this is your dwell start time
   v. Remove PPE and dispose of
   vi. Document start time, prescription, and volume of dwell

5. Drain
   b. After dwell time is completed, Don PPE and prepare to re-enter room
c. Open clamp on patient end of line
   i. You will note the drain bag on the floor begin to fill with fluid (check for clarity).
   ii. Allow 20 minutes for fluid to collect in drain bag
   iii. Remove PPE and dispose properly
d. After draining for approximately 20 minutes
   i. Clamp patient line
   ii. Note color of drained fluid
   iii. Hang drain bag onto scale and assess the amount of fluid collected
   iv. Record drain time, color of fluid, and volume output
e. Aseptically initiate next dwell as before or apply Iodine cap and infuse heparin if additional dwell is not needed
f. Clamp all lines before disposal to prevent leaks
g. Dispose of peritoneal effluent as per hospital infection control protocols

**Common PD issues:**
Slow drain or fill of dialysate
- Attempt to reposition patient (sometimes a patient will drain better when leaning more to one side)
- Determine no pericatheter leak
- Gently press on patient’s abdomen while trying to fill/drain
- Attempt to flush line with 50 mL sterile syringe of saline 1-3 times
- Ask nurse if patient has had bowel movement in the past 24 hours ○ Constipation can prevent adequate draining in PD patient. Implement increased bowel regimen as needed
- Check an Abdominal film for PD catheter placement, Constipation or other unanticipated complications
- Can try tPA for possible fibrin clot at this point as per protocol

Blood in the PD fluid
- Flush with 1.5% 500mLx3 or until the fluid clears, if does not clear consult surgery

Cloudy PD fluid
- Send the fluid for culture and cell count
- Start antibiotics prophylactically until the culture is available and then can customize treatment based on organism and sensitivities
PD catheter leak

- Check the integrity of the catheter for damage
- Decrease the dwell volume to 500mL and proceed with manual exchanges. If no acute metabolic needs can hold PD exchanges for 12-24 hours and then resume PD starting at low volume. If holding PD temporarily, place heparin 6000u/6mL in the transfer set as per protocol. Cap to close the transfer set.
- Place a new dressing as per the protocol

TfA Protocol

- instill 8cc of 1mg/cc (8mg total) into the transfer set/PD catheter (total volume of the catheter and transfer set usually 6-7cc)
- let dwell in the catheter for 60 min
- try to flush with 50cc NS. If good flow can attempt a regular infusion and dwell. If still not good flow can repeat X1.
- If still poor flow consult surgery

Adding Medication to the PD Fluid

- When adding anything soak the med port of the solution bag for 3 min with alcavis or other sterilizing fluid (alcohol can be used)
- When adding any medication soak the top of the bottle with sterilizing solution for 3 min and always change the needle and always use a clean needle before adding the heparin (or other medication) to the fluid

Record Keeping:

Document:
- Time of the exchange,
- Fill volume,
- Drain volume (can be weighed with the scale or estimated), and
- Effluent appearance (cloudy, clear)
- Exit site

Solution Strength:

Peritoneal dialysis solution comes in three strengths, which are color coded:

A) **Yellow** or 1.5%--This solution has a low glucose concentration and will lead to little or no ultrafiltration (fluid removal). The effluent drain volume may in fact be smaller than the fill volume.

B) **Green** or 2.5%--This solution contains a medium concentration of glucose and in most patients will lead to ultrafiltration (fluid removal).

C) **Red** or 4.25%--This solution will lead to the greatest amount of ultrafiltration (fluid removal). D) Icodextran--Used for overnight dwells (8-16 hours) (Baxter only)

The nephrologist will change the solution strength depending upon the patient’s hemodynamic status and fluid volume status.

Exit Site Care

- Clean exit site with normal saline. Tegaderm over exit site
- Administration of gentamycin cream 0.1% or mupirocin cream 2% to the exit site whenever the dressing is changed
- Avoid ointments as these may break down the polyurethane in the catheters.
Fresenius Stay Safe 1.5% Dextrose solution with tubing and drain bag

Fresenius transfer sets

Stay safe caps (Fresenius)
**PD CATHETER PLACEMENT**

Bedside technique description: From PD Surgeon Dr. Cheguevara Afaneh; other surgeons can use it potentially and it obviates the need for fluoroscopy

1. A right upper quadrant incision is made 3 cm lateral to the midline.
2. The subcutaneous tissue is dissected away from the anterior rectus sheath using monopolar energy and retractors.
3. Once the anterior rectus sheath is clearly exposed and clear of any subcutaneous tissue, it is sharply incised.
4. The muscle is then bluntly dissected away until the posterior rectus sheath is identified.
5. Two tonsil clamps are used to pull the posterior rectus sheath superiorly and away from the bowel. To avoid inadvertently grabbing the bowel, clamp the posterior rectus sheath on each side, then unclamp each clamp sequentially and re-clamping.
6. Sharply incise the posterior rectus sheath. A window into the peritoneal cavity is now achieved.
7. Advanced the dilator/sheath under direct visualization while pulling up on the clamps to create a potential space into the peritoneum. A 2-0 vicryl U-stitch is placed but not tied around the dilator/sheath.
8. Next, the dilator is withdrawn, and the sheath remains in place.
9. A 62.5 cm swan neck curl right-sided peritoneal dialysis catheter is introduced through the sheath after soaking it in heparinized saline and expelling all the air from the cuffs.
10. The sheath is snapped and withdrawn as the dialysis catheter is introduced. Care is taken to ensure the anterior line remained in the orientation as the catheter is advanced into the peritoneal cavity.
11. Once the sheath is fully withdrawn, the distal cuff is advanced into the rectus muscle.
12. The cuff is then secured to the posterior fascia by tying the 2-0 vicryl U stitch. This creates a tight seal and allows for initiation of emergent PD.
13. The anterior fascia is closed with 2-0 vicryl suture, taking care not to kink the tubing, allowing a window for the catheter to exit the anterior sheath. The catheter should be flushed at various points to ensure there is no kinking of the tubing with heparinized saline both before and after the catheter is tunneled.

**Tunneling the cuff**
1. The catheter dimensions and exit sites are measured.
2. A <1 cm exit site is made approximately 3-4 cm inferior and lateral to the introducer site.
3. The proximal end of the catheter is attached to the tunneler.
4. A subcutaneous tunnel is fashioned, and the catheter withdrawn through the exit site.
5. The tubing is separated from the tunneler. The cuff should clearly be 1-2 cm proximal to the exit site.
6. The connector is attached to the end of the PD catheter (usually included in the catheter set)
7. The transfer set (usually either Fresenius or Baxter) is attached before the sterile field is broken, and catheter should be flushed to assure flow because kinking under the skin can happen when it is tunneled.
8. ap if not being used immediately.
9. The introducer site is closed with deep dermal sutures with 3-0 vicryl. The skin is closed with 4-0 suture.

• Once access obtained recommend catheter to be flushed with peritoneal dialysis fluid 2L 1.5% or 2.5% dextrose solution with 500U/L (1000u total) Heparin added. The flush is 500cc infused and immediately drained. We repeat this for the entire 1500 or 2000cc bag. Can Start dwells at this time or hold overnight.
• Alternatively, after checking for proper placement and flushes, instill 6000u (6ml of 1000u/ml heparin) into the transfer set if not being used immediately otherwise after the solution is allowed to run in.

**PD training videos**
3. https://urldefense.proofpoint.com/v2/url?u=http-3A__players.brightcove.net_1992769035001_default-5Fdefault_index.html-3FvideoId-3D6032170902001&d=DwIFAg&c=j5oPp0OeBH1io48DtsedeElZfc04rx3ExJHeIIZuCs&r=Ue7cNPZQIfHsiq_gBP8xGslPqKXiv_AY8eJLMmMH4&m=liTkvGk0ifMJETAHrkY51edA1EVooyQsQtn4vTSnLM&s=fsSlZQ0NRIv6e3ieGGHTrKY1cxo74ExOXC0X6a99bAyg&c=4
4. https://www.youtube.com/watch?v=-FDbo_e2oAM
PD supplies for each site assuming 10-15 pts per site with product order numbers:

PD fluid (Dianeal/Extraneal (Baxter) or Stay Safe (Fresenius)) - the 2L low volume bags to start
Approximately 45-60 bags per patient for 2-week time period. Assuming 15 patients
\[15 \text{ days} \times 15 \text{ patients} \times 60 = 900 \text{ bags of solution.}
\] We recommend 2L bags. (need to adjust below numbers based on the anticipated needs at your institution)

- Dianeal (Baxter) 2L Boxes (6/box)
  - 1.5% Dextrose (5B9766)
  - 2.5% Dextrose (5B9876)
  - 4.5% Dextrose (5B9796)
  - Extraneal (Baxter)-For overnight dwells (8-16 hours) 1 bag per night per patient
  - 30 boxes of 2L (6 per box) (5B4986)
  - Stay Safe Fluid (Fresenius) 2L bags (5 per box)
    - 1.5% Dextrose (054-20221)
    - 2.5% Dextrose (054-20222)
    - 4.25% Dextrose (045-20224)

Ultraclamps (Baxter) (12/Box) or any tubing clamps (can buy on amazon)-use 2 per exchange per patient. Can wash and reuse
- 20 boxes (5C4957)

Minicaps (Baxter) (60/box) or Stay Safe Cap (Fresenius)(40 per box)
  - 60 Boxes (5C4466P)-Baxter
  - 80 Boxes (050-95012)-Fresenius

Spring Scale-recommend one per patient is best but, in a pinch, can share (or estimate). Also, can buy similar on Amazon
  - 20 scales (5K3582)-Baxter
  - Ohaus Spring Scale (36-8008-9)-Fresenius

Alcavis 50 (500ml/bottle) (Baxter) or ExSept (Fresenius)
  - 20 Bottles (5K4005)-Baxter
  - 20 Bottles (15117)-Fresenius

Transparent Dressings (50 per box) (Tegaderm or similar)
  - 5 Boxes (5K7579M)-Baxter

Transfer Set:
FMCNA Stay Safe Set 18 inch (050-95005)-start with 30 (one per patient needed) (Fresenius)
Minicap extended life PD Transfer set 6”(6/box) (5C4482) This is a change to the twist clamp and need extra so
new product # (Baxter)
  - 10 boxes (need extra transfer sets if using extension tubing)

Stay Safe Organizer (Fresenius)-one needed per patient (030-10807)- Makes it easier to use the stay safe bags but not essential. There is a holder too that connects to the IV poles, but I would not recommend as might risk the PD catheters getting inadvertently pulled out if the pole is moved.
  - Would start with 30 organizers (Fresenius)

Warming Device (5K3961) or heating pad or warmer used for CVVH solution can be used to warm PD fluid (not essential)
  - 15 warming devices

Sterile drain extension line, 12 feet (5C4464P)-Baxter only. For use if putting the fluid outside the room
  - 30 drain lines
  - 30 drain sets (026-20226, 10/box – Fresenius)
Catheter Placement:  15/each
Catheters: PD catheter kit: Merit VPL 511
Marcaine or lidocaine (what % is typically stocked and used)
OR basic tray or DPL kit
Scalpels: #5, #10, #11 Blades
1L NS for infusion to check placement needed at the time of placement
Sutures: 3-0 vicryl
  4.0 monocryl
  3-0 nylon
Transfer set (connection that stays on attached to the catheter)
Heparin 6ml (1000u/ml) to be infused by the surgeon and left to dwell in the catheter (including the transfer set) if not used immediately

Merit Supplies
1. Catheters: recommend the classic catheters. They come in three sizes. The difference is the length and distance between cuffs. Should get 15-20 to start
   • Classic adult small -3 catheters (CF5250)-Or avoid, can primarily use standard size.
   • Classic adult standard-12 catheters (CF5260)
   • Classic adult large-5 catheters (CF5270)
2. VP-511 PD implantation system 15-20 kits-one per patient needed (can be substituted with OR kits if not available)
3. Repair kit (CE-1400)-I think should have 2 in case the cap or connector is damaged
4. Faller Trochar (FT1100)-apparently helps with difficult patients. 3 (not essential but can be helpful)
5. Fluid administration kit-used to flush post implantation. (K08-02385) (not essential)

The clinical educator from Merit: Jacquie Logue 801-712-1321
A 12-foot cycler standard drain line extension (life hack) can extend from usual PD catheter transfer set by 12 feet (Baxter only). A second transfer set is attached at the end of the extension. All CAPD modalities can be performed either outside of the patient room or at a distance that is consistent with COVID-19 distancing recommendations. Multiple extenders can fit together so it can be even 24 ft.

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