KI REPORTS
KIReports.org



# Peritoneal Dialysis for Acute Kidney Injury During the COVID-19 Pandemic in New York City



Divya Shankaranarayanan[1], Sanjay P. Neupane[1], Elly Varma[1], Daniil Shimonov[1], Supriya Gerardine[1], Aarti Bhasin[1], Perola Lamba[1], Lorenz Leuprecht[1], Thalia Salinas[1], Cheguevara Afaneh[2], Omar E. Bellorin-Marin[2] and Vesh Srivatana[1,3]

[1]Division of Nephrology and Hypertension, Weill Cornell Medicine, New York, New York, USA; [2]Department of Surgery, Weill Cornell Medicine, New York, New York, USA; and [3]The Rogosin Institute, New York, New York, USA

**Correspondence**: Vesh Srivatana, New York-Presbyterian Hospital Weill Cornell Medicine, The Rogosin Institute, 505 E 70th Street, Suite HT-140 Box #2, New York, New York 10021, USA. E-mail: ves2009@nyp.org

**Received 28 May 2020; revised 2 July 2020; accepted 15 July 2020; published online 23 July 2020**

*Kidney Int Rep* (2020) **5,** 1532–1534; https://doi.org/10.1016/j.ekir.2020.07.017


See Commentary on Page 1381

The coronavirus disease 2019 (COVID-19) pandemic resulted in extraordinary increase in the number of patients requiring renal replacement therapy (RRT), high rate of clotting in continuous RRT (CRRT) circuits, limited dialysis supplies and shortages of dialysis staff due to illness or quarantine.[1–5] This created an opportunity to use peritoneal dialysis (PD) for acute kidney injury (AKI).

## METHODS

Patients treated with acute PD (AKI-PD) at our New York City hospital from April 1, 2020, to April 30, 2020, were retrospectively analyzed. Overall, 40 patients were screened and 11 were suitable for AKI-PD. AKI was defined as any patient with Acute Kidney Injury/Network (AKIN) stage 1 or greater; all patients in the cohort were AKIN stage 3. The nephrology consultant determined the need and timing for RRT initiation based on usual clinical indications. These patients were then referred to the AKI-PD team composed of an attending nephrologist and surgeon to determine candidacy for AKI-PD. Patients were excluded if they had significant abdominal surgical scars, uncorrected hernias, high likelihood of prone ventilation, active gastrointestinal issues such as ileus or small bowel obstruction, or were on dual antiplatelet therapy with aspirin and clopidogrel. Body mass index greater than 30 kg/m$^2$ was a relative contraindication and candidacy discussed on a case-by-case basis. All 11 patients underwent bedside placement of a swan-neck double-cuff Tenckhoff tunneled PD catheter, with additional purse-string suture at the surgeon's discretion. Bedside placement of the catheters by a surgeon and an assistant alone was chosen to limit COVID-19 exposure of additional health care professionals. All patients received a bowel regimen to ensure 1 to 2 bowel movements daily, the choice of laxative was at the discretion of primary treating service.

## RESULTS

The median age of the cohort was 65 years (interquartile range [IQR]: 52–76); predominantly (91%) male (Table 1). Median body mass index was 26 kg/m$^2$ (IQR: 23–30). Two patients had history of chronic kidney disease. One patient had a history of abdominal surgery. Median Sequential Organ Failure Assessment score was 9 (IQR: 6–10). All patients were on invasive mechanical ventilation and 45% required vasopressors. Acute respiratory distress syndrome, as defined by the Berlin criteria,[6] was mild in 73% and moderate in 27%. Median baseline creatinine was 1 mg/dl (IQR: 0.9–1.44). Median time from admission to the development of AKI was 1 day (IQR: 0–3). Median peak creatinine was 6.6 mg/dl (IQR 5.6–8.15) and median daily urine output was 230 ml (IQR: 150–392) at initiation of RRT. In 73% of the patients, CRRT or intermittent hemodialysis was used as the initial RRT modality and switched to PD at a later date; time interval between discontinuation of CRRT/hemodialysis and initiating PD was less than 24 hours in these patients. CRRT circuit clotting was the primary reason for switching to PD in 2 patients.

**Table 1.** Baseline characteristics, PD prescription and outcomes

| | Total $N = 11$ |
|---|---|
| Baseline characteristics | |
| Age, median (IQR) | 65 (52–76) |
| Male, *n* (%) | 10 (91) |
| Race, *n* (%) | |
| Asian | 6 (55) |
| White | 2 (18) |
| Black | 1 (9) |
| Declined | 2 (18) |
| Ethnicity, *n* (%) | |
| Hispanic | 1 (9) |
| Comorbidities, *n* (%) | |
| Hypertension | 7 (64) |
| Diabetes mellitus | 5 (45) |
| Chronic kidney disease | 2 (18) |
| Coronary artery disease | 2 (18) |
| History of abdominal surgery | 1 (9) |
| Body mass index, kg/m$^2$ median (IQR) | 26 (23–30) |
| Clinical characteristics before PD initiation | |
| Severity of ARDS,[a] *n* (%) | |
| Mild | 8 (73) |
| Moderate | 3 (27) |
| Severe | 0 |
| SOFA[b] score, median (IQR) | 9 (6–10) |
| Daily urine output, ml, median (IQR) | 230 (150–392) |
| Blood urea nitrogen, mg/dl, median (IQR) | 99 (70–119) |
| Creatinine, mg/dl, median (IQR) | 6 (4.7–6.4) |
| Serum albumin, g/dl, median (IQR) | 1.6 (1.5–1.7) |
| PD prescription | |
| Modality of PD, *n* (%) | |
| Manual PD | 6 (55) |
| Automated PD | 5 (45) |
| Time from PD catheter insertion to start of PD, h, *n* (%) | |
| <24 | 6 (55) |
| 24–48 | 5 (45) |
| Dwell volume, ml, *n* (%) | |
| 1000 | 5 (45) |
| 1500 | 1 (9) |
| 2000 | 5 (45) |
| Therapy volume in liters per 24 h | |
| Manual PD, median (IQR) | 8 (7–8) |
| Automated PD, median (IQR) | 8 (8–9.9) |
| Total therapy time in h,[c] median (IQR) | 24 (12–24) |
| Daily urine output, ml, median (IQR) | 497 (137–1612) |
| Daily ultrafiltration, ml, median (IQR) | 681 (262–1351) |
| Laboratory values at 30-d follow-up, median (IQR) | |
| Blood urea nitrogen, mg/dl | 44 (24–61) |
| Creatinine, mg/dl | 1.9 (1.3–3.1) |
| Serum albumin, g/dl | 2.1 (1.4–2.6) |
| PD catheter outcomes, *n* (%) | |
| Leak | 1 (9) |
| Peritonitis | 0 (0) |
| Patient outcomes, *n* (%) | |
| Renal recovery[d] | 6 (55) |
| Death | 4 (36) |
| Alive on hemodialysis | 1 (9) |

ARDS, acute respiratory distress syndrome; IQR, interquartile range; PD, peritoneal dialysis.
[a]Severity of ARDS defined per Berlin Criteria: mild (200 mm Hg < PaO2/FIO2 ≤ 300 mm Hg), moderate (100 mm Hg < PaO2/FIO2 ≤ 200 mm Hg), and severe (PaO2/FIO2 ≤ 100 mm Hg).
[b]Sequential Organ Failure Assessment score.
[c]Total therapy time for all manual PD was 24 h. Four exchanges were performed in 24 h.
[d]Renal recovery was defined as no longer requiring renal replacement therapy.

At the time of PD initiation, median blood urea nitrogen was 99 mg/dl (IQR: 70–118), creatinine 6 mg/dl (IQR: 4.7–6.4), and serum albumin 1.6 g/dl (IQR: 1.5–1.7). Six patients had serum potassium >5 mmol/dl and 1 had >6 mmol/dl. Median time for potassium levels to return to normal range was 2 days (IQR: 0–3) using PD combined with medical therapies, including oral potassium binder, insulin, and diuretics in these 7 patients. Median time for correction of metabolic acidosis was 3 days (IQR: 0–4). While on PD, the median daily urine output was 497 ml (IQR: 137–1612) and median daily ultrafiltration was 681 ml (IQR: 262–1351). Seven of the 11 patients were continued on diuretics. At 30 days, median blood urea nitrogen, creatinine, and albumin were 44 mg/dl (IQR: 24–61), 1.9 mg/dl (IQR: 1.3–3.1), and 2.1g/dl (IQR: 1.4–2.6), respectively.

The median time from diagnosis of AKI to PD catheter insertion was 5 days (IQR: 2–14). The time from PD catheter placement to initiation of PD was less than 24 hours in 55% and between 24 to 48 hours in the remainder. The decision to start on continuous ambulatory PD or automated PD (APD) was based on the availability of cyclers and nursing familiarity with each modality. Five of the 6 patients who were started on continuous ambulatory PD tolerated an initial dwell volume of 2000 ml with no leaks; the sixth patient was switched to APD when a cycler was available. For those on continuous ambulatory PD, the initial prescription was 2000 ml every 6 hours. In the 5 patients initiated on APD, the initial dwell volume was between 1000 and 1500 ml and total therapy volume of 8000 ml to 10,500 ml over 12 hours total (1000 ml × 8 or 1500 ml × 7), which is in keeping with recently published acute PD protocols.[7] In 4 patients the abdomen was empty while off APD; however, 1 patient was treated with consecutive 12-hour treatments due to hyperkalemia until the potassium normalized. In terms of ventilator parameters, plateau pressures were less than 30 cm $H_2O$ in all patients, except 1 patient with moderate-to-severe acute respiratory distress syndrome with plateau pressure of 33 to 38 cm$H_2O$. No changes in plateau pressure were noted while on PD for any patients and none of the patients were in prone position while on PD.

The median hospital length of stay was 42 days (IQR: 19–70). Four patients (36%) died and the median time from AKI to death was 17 days (IQR: 14–22). Six patients had renal recovery defined as dialysis independence as determined by the treating nephrologist. Median time from AKI to renal recovery was 37 days (IQR: 25–41). One patient was discharged and remained dialysis dependent. One patient who recovered renal function remains hospitalized at the time of writing.

Regarding PD catheter outcomes, patients were treated with PD for a median duration of 14 days (IQR:

10–20). Ten catheters (91%) remained functional during the duration of the follow-up. One patient was switched to CRRT due to primary PD catheter nonfunction; this patient had a body mass index greater than 35 kg/m$^2$ and a history of appendectomy. There was one episode of leak that was resolved with temporary reduction of dwell volume and the patient was able to continue PD. There were no episodes of peritonitis observed. One patient was switched to hemodialysis at the time of discharge to a skilled nursing facility that did not have PD available. One patient was converted to CRRT before death at the discretion of the intensivist, although the PD catheter was functional. Two patients required CRRT/hemodialysis supplementation for variable ultrafiltration and active gastrointestinal bleeding but were able to return to PD before renal recovery.

## DISCUSSION

In our cohort, 6 patients (54%) had renal recovery with a median follow-up of 35 days. Remarkably, these 6 patients survived their acute critical illness, and were all subsequently discharged. We hypothesize that preservation of residual renal function using PD may have contributed to the high rate of renal recovery observed.[8] Two of our patients converted from CRRT to PD due to repeated filter clotting. We did not observe any bleeding complications in our cohort, although we had the benefit of experienced operators. We hypothesize that hypercoagulable patients with COVID-19 may potentially have a lower risk of bleeding complications and consequently be excellent candidates for PD. The PD prescriptions used were variable, but each able to control metabolic parameters and provide adequate volume control.

The primary limitation of our study was the small number of patients. However, this cohort represented approximately 20% of all patients requiring RRT in our hospital at the peak of the demand. Our report demonstrates the value of even a modest amount of PD in a time of crisis to be able to provide RRT for all patients who need it. In addition, although all patients were mechanically ventilated and critically ill, there is a potential for selection bias resulting in the high observed rate of renal recovery. Long-term outcome studies in a larger cohort are needed to confirm these findings. In summary, the practical utility and potential for a higher rate of renal recovery combines for an attractive and unique rationale for the use of AKI-PD in the critically ill COVID-19 population.

## DISCLOSURE

VS reports speaker fees from Baxter International. All the other authors declared no competing interests.

## ACKNOWLEDGMENTS

We acknowledge the extraordinary effort of our nurses and staff who are on the front lines of the COVID-19 crisis each day. Your patients and doctors thank you.

## SUPPLEMENTARY MATERIAL

Supplementary File (PDF)

**Supplementary Methods.**

## REFERENCES

1. Goldfarb DS, Benstein JA, Zhdanova O, et al. Impending shortages of kidney replacement therapy for COVID-19 patients. *Clin J Am Soc Nephrol*. 2020;15:880–882.
2. Goyal P, Choi JJ, Pinheiro LC, et al. Clinical characteristics of Covid-19 in New York City. *N Engl J Med*. 2020;382:2372–2374.
3. Hirsch JS, Ng JH, Ross DW, et al. Acute kidney injury in patients hospitalized with Covid-19. *Kidney Int*. 2020;98:209–218.
4. Cummings MJ, Baldwin MR, Abrams D, et al. Epidemiology, clinical course, and outcomes of critically ill adults with COVID-19 in New York City: a prospective cohort study. *Lancet*. 2020;395:1763–1770.
5. Sise ME, Baggett MV, Shepard J-AO, et al. Case 17-2020: a 68-year-old man with covid-19 and acute kidney injury. *N Engl J Med*. 2020;382:2147–2156.
6. Ferguson ND, Fan E, Camporota L, et al. The Berlin definition of ARDS: an expanded rationale, justification, and supplementary material. *Intensive Care Med*. 2012;38:1573–1582.
7. Srivatana V, Aggarwal V, Finkelstein FO, et al. Peritoneal dialysis for acute kidney injury treatment in the United States: brought to you by the COVID-19 pandemic. *Kidney360*. 2020;1:410–415.
8. Jansen MA, Hart AA, Korevaar JC, et al. Predictors of the rate of decline of residual renal function in incident dialysis patients. *Kidney Int*. 2002;62:1046–1053.