Brief report

A year-long quality improvement project on fluid management using blood volume monitoring during hemodialysis

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Abstract

Background:  
Inadequate removal of extracellular volume markedly increases blood pressure and contributes to high morbidity and mortality in hemodialysis patients. Advances in fluid management are needed to improve clinical outcomes. The aim of this quality improvement project was to examine the advantages of using a hematocrit-based, blood volume monitor (Crit-Line*) for 12 months, as part of a clinic-wide, fluid management program in one dialysis facility.

Methods:  
Forty-five individuals were receiving hemodialysis at one facility at project initiation and are included in this analysis. Monthly averaged clinical parameters (dialysis treatment information, blood pressures, blood volume, and laboratory data) were compared from Months 1–12. Analyses were conducted overall and according to the presence/absence of hypertension at Month 1 (Baseline). Antihypertensive medication changes were assessed for patients with hypertension at Month 1.

Results:  
Average hemodialysis treatment time (+10.6 minutes, \( p = 0.002 \)), eKt/V (+0.25, \( p < 0.001 \)) and online clearance (+0.21, \( p < 0.0001 \)) increased significantly in Month 12 versus Month 1. Average albumin levels and normalized protein catabolic rate increased from Month 1 to 12. Post-dialysis systolic blood pressure (SBP) decreased by Month 12 (\( p = 0.003 \)). In hypertensive patients (SBP ≥ 140 mmHg in Month 1), there were significant differences in pre- and post-dialysis SBP between Month 1 and Month 12 (pre-hemodialysis: \( p = 0.02 \); post-hemodialysis: \( p = 0.003 \)), and antihypertensive medication use decreased in 29% of patients, while only 11% increased use. Treatment time in hypertensive patients increased by 15.4 minutes (\( p = 0.0005 \)).

Limitations:  
This was a single, clinic-wide, quality improvement project with no control group. All data analyzed were from existing clinical records, so only routinely measured clinical variables were available and missing data were possible.

Conclusions:  
During this year-long fluid management quality improvement project, decreases in post-dialysis SBP and increases in adequacy and treatment time were observed. Patients with hypertension at Month 1 experienced reductions in pre-dialysis SBP and antihypertensive medications.

*Crit-Line is a trademark of Fresenius Medical Care Holdings, Inc. or its affiliated companies.
Introduction

Volume or fluid overload is a major problem in chronic hemodialysis (HD) patients, and studies have linked volume overload to increased morbidity and mortality\textsuperscript{1}. Fluid volumes >15% of the extracellular volume (ECV) (i.e., ~2.5 L of excess fluid), occur in 25–28% of all HD patients\textsuperscript{2,3}. Several large follow-up studies demonstrated that overhydrated HD patients have increased mortality risk compared with normohydrated HD patients\textsuperscript{4–7}. ECV expansion with subsequent fluid overload may be the most important contributor to hypertension in HD patients\textsuperscript{8}. At the start of dialysis, 80–90% of end-stage renal disease patients are hypertensive and have increased risk of cardiovascular disease\textsuperscript{9,10}. To assist with blood pressure (BP) control, many HD patients are prescribed antihypertensive medications\textsuperscript{5}. Although this approach may have beneficial antihypertensive effects, these medications can affect compensatory vasoconstriction processes, and patients might remain fluid overloaded. Thus, volume control should be an integral component of BP management and achievement of normovolemia – a key target of therapy\textsuperscript{5,11}.

Improvements in fluid management have the potential to positively impact clinical outcomes in HD patients\textsuperscript{12–15}. Assistive technologies, including blood volume (BV) monitoring, have been employed to examine and track fluid status changes. These technologies may encourage greater focus on improving excess volume removal and fluid management\textsuperscript{12}. Previous studies indicate that BV monitoring during HD could be used to assess appropriateness of target weight\textsuperscript{16–18}. Some studies examined BV monitoring in clinical settings, but results have been inconsistent\textsuperscript{19–21}.

This report describes clinical parameter changes over 12 months of a quality improvement project on fluid management using BV monitoring as part of the daily clinic routine at one dialysis facility.

Methods

BV monitor used in this quality improvement project

The BV monitor (Crit-Line\textsuperscript{*}) used is a hematocrit (HCT) based BV monitor that is 510k cleared to non-invasively and continuously measure percentage change in BV, HCT, oxygen saturation, and calculate hemoglobin based on HCT.

\textsuperscript{*}Crit-Line is a trademark of Fresenius Medical Care Holdings, Inc. or its affiliated companies.

Design, setting, and duration

This report examines the first 12 months (April [Month 1] through March [Month 12]) of a clinic-wide fluid management quality improvement project in one Southeastern United States dialysis facility. All patients receiving dialysis at this facility were eligible for the quality improvement project. This report is limited to the patients in the facility at the quality improvement project start (n = 45), allowing the establishment of baseline in Month 1 before BV monitors were installed.

Fluid management initiatives

One BV monitor was installed on every HD chair during the first week of Month 2. To allow for staff training and acclimation, interventions began 1 week later for every HD treatment. Concurrent with standard of care that includes assessment of patients’ vital signs and safety parameters every 30 minutes (e.g., BP, pulse, blood flow rate, dialysis flow rate, vascular access check, signs and symptoms), staff were instructed to record percentage change in BV and HCT. At the discretion of the physician, the nurse was allowed to adjust the ultrafiltration (UF) goal up to 200 ml every 30 minutes to obtain a gradual decrease in percentage change BV, as indicated on the BV monitor. To assess whether vascular compartment refill was present at the end of HD, the UF was turned off during the last 15 minutes of the HD session. If there was a decrease in HCT of 0.5 during those 15 minutes, then the patient’s target weight could be adjusted for the next treatment. If a patient became symptomatic or hypertensive, standard clinic procedures were followed including: reducing UF goal, reducing UF to minimum for 10–15 minutes, lowering dialysate temperature from the standard of 37 to 35.5°C, repositioning patient, or administering saline. Oxygen therapy was administered if oxygen saturation fell below 90% for fistula or grafts, or below 60% for catheters. If a patient had large interdialytic fluid gains that could not be removed during the treatment, treatment length could be extended or an extra treatment scheduled. Patients were dialyzed with a 137 mmol/L dialysate sodium, unless a lower sodium concentration was ordered. Ultrafiltration profiles and sodium modeling were not used. Finally, nurses and dieticians stressed the importance of fluid and sodium restriction to the patients.

Clinical and treatment parameters

The following data were routinely available from an electronic data warehouse: pre- and post-HD body weight, interdialytic weight gain (IDWG), systolic blood pressure (SBP) and diastolic blood pressure (DBP), pre-HD serum phosphorus, albumin, and normalized protein catabolic rate (nPCR); as well as information on treatment time.
and adequacy (total eKt/V and on-line clearance [OLC]). The monthly averages for continuous variables were calculated per person. Data on antihypertensive medications were collected quarterly from patient self-reports, bottle checks, and discharge summaries by a nurse. Data recorded on the treatment sheets regarding intradialytic BP changes, symptoms, and interventions made by staff (e.g., saline administration) were reviewed for one week each month from Month 2 (first week of Month 2 after BV monitor installed, but before interventions began) to Month 9 of the project by a nurse. Symptoms during dialysis included all patient-reported discomfort such as cramps, nausea, headache, and general malaise (e.g. ‘not feeling well!’). Administration of extra saline (excluding saline needed to start/end HD treatment and any flushes due to clotting or heparin-free treatments) and instances when the UF was set to off/minimum (excluding refill checks) were also recorded. For the current analysis, hypotension was defined according to the National Kidney Foundation Kidney Disease Outcome Quality Initiative (NKF KDOQI) Guidelines as a drop of 20 mmHg in BP or a drop of 10 mmHg in mean arterial pressure (MAP) associated with symptoms. Symptom and SBP drop were not required to occur simultaneously, only within the same dialysis session. BV monitor data including percentage change in BV were captured electronically. Treatments with obvious errors that would impact the ending percentage change in BV were removed including: improbably low starting HCT, short duration, and technical errors (e.g., sensor clip removal/shift). Hospital admissions data were collected and these ICD-9 codes were considered possibly fluid related: 276.6, 276.69, 398.91, 402.01, 402.11, 402.91, 404.03, 404.11, 404.91, 428.0, 428.2, 428.21, 428.22, 428.23, 428.3, 428.31, 428.32, 428.33, 428.4, 428.41, 428.42, 428.43, 514, 518.4, 782.3, 786.05, 1075, 34736. Person-time for calculation of hospital rates was summed over all patients using (last HD date - first HD date)/365. Fluid-related hospital admission rates are reported cumulatively over 12 months, not monthly, due to small sample size and infrequent occurrence.

Analyses and statistical methods

Descriptive analyses were performed on data from all 45 patients. Paired t-tests were used to compare clinical outcomes in Month 1 to Month 12 for patients with complete data during those months (n = 36). To account for repeated observations over time on the same patients and utilize incomplete follow-up information, mixed effects linear regression modeling was used to estimate the change per month (n = 45). Patients were stratified according to the presence (SBP ≥ 140 mmHg) or absence (SBP < 140 mmHg) of hypertension at Month 1. To assess the relation between antihypertensive medication changes and BP changes among hypertensive patients, SBP slopes across categories of medication changes were constructed and analyzed. SBP changes were assessed based on the statistical significance of SBP slope using linear regression.

Results

Patient participation and demographics

Forty-five patients were included in the current analysis. Thirty-six patients were observed through Month 12; three patients transferred dialysis facility, one patient moved to hospice, and five patients died. Death certificates and discharge summaries, where appropriate, were reviewed for deceased patients. Causes of death for these patients were (1) cancer, (2) chronic obstructive pulmonary disease with multiple co-morbidities, (3) pneumonia, and (4, 5) sudden death arrhythmia. There were 11 possible fluid-related hospitalizations over the year (0.28 per patient-year). Patient demographics are shown in Table 1. On average, patients were aged 59 years with dialysis vintage of 3.6 years. Fifty-six percent of the participants were male, 53% were Black or African American, and 27% were Hispanic. At the start of the project, 80% had a fistula or graft as their vascular access. The average serum sodium level was 138.8 mmol/L, and the standard dialysate sodium concentration was 137 mmol/L.

Changes in clinical parameters (all patients)

Table 2 describes the monthly changes in clinical parameters for all patients. Comparisons were made between Months 1 and 12 using t-tests for the patients with data available for both months. There were significant changes in the average treatment time (+10.6 minutes, p = 0.002), post-HD SBP (-10.6 mmHg, p = 0.003), eKt/V (+0.25, p < 0.0001) and OLC (+0.21, p < 0.0001) between Month 1 and Month 12. The average albumin levels and nPCR showed increasing trends, with average changes of 0.07 (p = 0.09) and 0.06 (p = 0.06), respectively. There was a trend toward serum phosphorus decreases (-0.9 mg/dL, p = 0.001). There was minimal overall change in percentage BV change (-0.1%, p = 0.89), post-HD weight (-0.32 kg, p = 0.6), and IDWG (-0.02 kg, p = 0.9).

A mixed effects model was used to estimate changes per month for the complete sample (n = 45). On average, estimated monthly change was -0.5 mmHg for pre-HD SBP (p = 0.09), -1.4 mmHg for post-HD SBP (p < 0.0001), 1 minute for treatment time (p = 0.002), 0.02 for eKt/V (p < 0.0001), and 0.01 for OLC (p = 0.002). There was no statistically significant trend toward decreasing pre- and post-HD weights or IDWG. The monthly mean...
percentage BV changes ranged from $-6.5 \pm 2.9\%$ to $-7.9 \pm 3.1\%$ at treatment end and patients lost an average of 2.2–2.7 kg per treatment.

**Intradialytic morbidity and interventions**

In total, 936 treatment sheets from all available treatments from one week each month were reviewed for Months 2–9. For Month 2, the week during the BV monitor acclimation period (when treatment changes were not made based on percentage change BV) was chosen, serving as the baseline. Figure 1 shows the distribution of intradialytic events and intervention recorded Months 1–8. Intradialytic hypotension and symptoms such as cramping, general malaise, or any other documented patient discomfort were variable across months and throughout the quality improvement project. The percentage of treatments for which saline was administered beyond routine dialysis initiation and discontinuation decreased compared to Month 2 (16.9%) in Months 3, 4, 5, and 9, while there was an increase in Months 6, 7, and 8. The percentage of treatments during which clinic staff turned the UF to minimum or off (not including refill checks) was the highest during Month 2 (36.9%) and lowest for Month 7 (9.6%). Thirty-seven patients (82%) experienced at least one hypotensive episode during the year.

**Stratification by baseline hypertension**

Patients were stratified into two groups for this current report based on mean pre-HD SBP during Month 1. Twenty-eight patients had a mean SBP $\geq 140\text{ mmHg}$ (‘Baseline Hypertensive’) and 17 patients had a mean SBP $< 140\text{ mmHg}$ (‘Baseline Normotensive’) during Month 1.

Except for differences in phosphorous levels, the Baseline Normotensive group did not show significant differences in any clinical parameters recorded (Supplemental data). In these patients, serum phosphorus levels decreased from $6.0 \pm 1.8\text{ mg/dL}$ in Month 1 to $4.7 \pm 1.1\text{ mg/dL}$ in Month 12 ($p = 0.01$). In 10 of the 12 months, phosphorus levels were within the KDOQI recommended range of 3.5–5.5 mg/dL (1.13 and 1.78 mmol/L).

Table 3 describes monthly changes in clinical parameters in the Baseline Hypertensive group. Comparisons were made between Month 1 and Month 12 using t-tests for the Baseline Hypertensive patients with data from both months. There were significant increases in the average dialysis treatment time (15.4 minutes, $p = 0.0005$), the average eKt/V (0.28, $p = 0.0002$), and average OLC (0.22, $p = 0.0001$). There were significant decreases in the pre- and post-HD SBP (pre-HD: $-8.9\text{ mmHg}$, $p = 0.02$; post-HD: $-15.3\text{ mmHg}$, $p = 0.0003$) and phosphorous levels ($-0.71\text{ mg/dL}$, $p = 0.02$). Although the increase in albumin levels did not reach statistical significance, the increase in nPCR was statistically significant (0.08 g/kg/day, $p = 0.02$).

A sub-analysis was conducted where nine patients with increased prescribed treatment times were removed, in order to assess the change in average eKt/V without the influence of prescribed treatment time changes. These patients had an increase in prescribed treatment time for these reasons: phosphorus control (3), adequacy (3), excess fluid gains (2), and non-adherence (1). In patients without prescribed treatment time increase, average delivered treatment time changed minimally (6.1 minutes), comparing Month 1 and 12. However, there was a statistically significant increase in average eKt/V (0.24, $p = 0.02$). The difference was similar to the increase seen overall in the hypertensive patients (0.28).

Figure 2 shows the average pre- and post-HD SBP for Baseline Hypertensive patients with complete data for each month ($n = 25$). This allows comparison of monthly means with the same population across time. The highest average pre-HD SBP occurred in Month 1 (163.4 mmHg) and the lowest average pre-HD SBP was in Month 7 (154.2 mmHg). The average post-SBP in Month 1 was 149.7 mmHg, and it reached the lowest level in Month 12 (136.1 mmHg).

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**Table 1. Patient demographics and treatment parameters at baseline.**

|                          | All patients ($n = 49$) | Patients with hypertension at baseline ($n = 28$)* | Patients with normotension at baseline ($n = 17$)** |
|--------------------------|-------------------------|------------------------------------------------------|--------------------------------------------------|
| Male (%)                 | 56                      | 68                                                   | 35                                              |
| Hispanic (%)             | 27                      | 32                                                   | 18                                              |
| Age (years)              | 59 ± 17                 | 58 ± 18                                              | 60 ± 16                                         |
| Dialysis Vintage (years) | 3.6 ± 3.3               | 3.2 ± 2.8                                            | 4.3 ± 4.1                                       |
| % with Fistula or Graft  | 80                      | 86                                                   | 71                                              |
| Serum Sodium (mmol/L)    | 138.8 ± 2.7             | 138.6 ± 2.8                                          | 139.2 ± 2.5                                     |
| Dialysate Sodium (mmol/L)| 137 ± 0                 | 137 ± 0                                              | 137 ± 0                                         |

*Pre-dialysis SBP $\geq 140\text{ mmHg}$ during Month 1.

**Pre-dialysis SBP $< 140\text{ mmHg}$ during Month 1.
Table 2. 

| Month | Pre-HD weight (Kg) | Post-HD weight (Kg) | Pre-HD SBP (mmHg) | Post-HD SBP (mmHg) | eKt/V | OLC | IDWG (Kg) | Pre-HD SBP change (mmHg) | p value |
|-------|-------------------|--------------------|-------------------|-------------------|-------|-----|----------|---------------------------|---------|
| 1     | 210.23            | 82.32              | 201.23            | 83.22             | 0.08  | 0.21| 1.29     | 0                      | 0.002   |
| 2     | 212.23            | 83.23              | 211.23            | 84.23             | 0.09  | 0.22| 1.33     | 0                      | 0.001   |
| 3     | 216.23            | 86.23              | 211.23            | 87.23             | 0.10  | 0.23| 1.47     | 0                      | 0.001   |
| 4     | 217.23            | 87.23              | 211.23            | 88.23             | 0.11  | 0.24| 1.61     | 0                      | 0.001   |
| 5     | 218.23            | 88.23              | 211.23            | 89.23             | 0.12  | 0.25| 1.75     | 0                      | 0.001   |
| 6     | 219.23            | 89.23              | 211.23            | 90.23             | 0.13  | 0.26| 1.90     | 0                      | 0.001   |
| 7     | 220.23            | 90.23              | 211.23            | 91.23             | 0.14  | 0.27| 2.05     | 0                      | 0.001   |
| 8     | 221.23            | 91.23              | 211.23            | 92.23             | 0.15  | 0.28| 2.20     | 0                      | 0.001   |
| 9     | 222.23            | 92.23              | 211.23            | 93.23             | 0.16  | 0.29| 2.35     | 0                      | 0.001   |
| 10    | 223.23            | 93.23              | 211.23            | 94.23             | 0.17  | 0.30| 2.50     | 0                      | 0.001   |
| 11    | 224.23            | 94.23              | 211.23            | 95.23             | 0.18  | 0.31| 2.65     | 0                      | 0.001   |
| 12    | 225.23            | 95.23              | 211.23            | 96.23             | 0.19  | 0.32| 2.80     | 0                      | 0.001   |

A mixed effects model was used to estimate the changes per month for all baseline hypertensive patients (n = 28). On average, estimated monthly change was −0.7 mmHg for pre-HD SBP (p = 0.04), −1.9 mmHg for post-HD SBP (p < 0.0001), 1.5 minutes for treatment time (p = 0.001), 0.02 for eKt/V (p < 0.0001), and 0.01 for OLC (p = 0.007). There was no statistically significant decrease in pre- or post-HD weights or interdialytic weight gain.

### Antihypertensive medication changes in patients with baseline hypertension

To determine whether the decreases observed in SBP among baseline hypertensive patients were due to increases in antihypertensive medications, the trajectory of SBP slopes were compared within categories of antihypertensive medication change. Cumulative data through Month 12 are presented in Table 4.

The 28 baseline hypertensive patients were categorized into three groups: those that showed a decrease in the average change in SBP (SBP Δ), those who showed no change in SBP, and those who showed an increase in SBP Δ. In the Decrease (n = 13), No Change (n = 10), and Increase groups (n = 5), the SBP Δ was −25.7 ± 20, −1.1 ± 6.4, and 19 ± 8.3 mmHg, respectively. Thirty-one percent of patients in the Decrease group had reduction in their antihypertensive medications (half stopped antihypertensive medications entirely), antihypertensive medications increased in 15%, were unchanged in 15%, and changed without clear increase or decrease in 39%. Overall, antihypertensive medications were reduced for eight patients (29%, 3/8 stopping all antihypertensive medications), increased for three (11%), unchanged for seven (25%), and varied in 10 (36%).

### Discussion

In this ongoing quality improvement project, BV monitoring was used as a tool to improve overall fluid management in HD patients. Over the 12 month period, a decrease in post-HD SBP and increase in adequacy and treatment time were observed. After stratification by baseline hypertension (pre-HD SBP ≥ 140 mmHg), further statistically significant changes were noted. There were significant increases in the average dialysis treatment time (15.4 minutes, p = 0.0005), the average eKt/V (0.28, p = 0.0002), and the average OLC (0.22, p = 0.0001). There were significant decreases in the pre- and post-HD SBP (pre-HD: −8.9 mmHg, p = 0.02; post-HD: −15.3 mmHg, p = 0.0003) and phosphorous levels (−0.71 mg/dL, p = 0.02). The lowering of SBP was not associated with increased use of antihypertensive medications. There was a trend toward improvement in nutritional markers with
a statistically non-significant increase in albumin levels (0.07; \( p = 0.09 \)) and statistically significant increase in nPCR (0.08 g/kg/day, \( p = 0.02 \)). Longitudinal data analysis techniques supported these findings.

Despite improvements in BP control, adequacy and nutritional markers, no statistically significant differences were observed in the mean monthly percentage change BV, post-HD weight, or IDWG. There was an initial lowering of percentage change BV in the earlier months, but this was not sustained. The duration of this quality improvement project is longer than most published BV monitoring projects and monthly means of percentage change BV may obscure smaller changes within the month. However, Patel and colleagues demonstrated that BV monitoring led to improved post-HD SBP control and reduction in antihypertensive medications, without significant weight change in a pediatric HD population over 6 months, possibly due to gain in ‘true weight’\(^{23}\). In the present study, the lack of persistent and significant lowering of weights could be related to concomitant improvement in patients’ nutritional status. This is supported by observed increases in nPCR and serum albumin values. Other studies have suggested that hypervolemia may contribute to hypoalbuminaria and malnutrition, and elevated nutritional marker levels, such as nPCR and albumin, may result in increased lean body mass\(^{24−26}\). It is worth noting that seasonal effects on factors such as weight may also obscure smaller changes over time\(^{27}\).

Antihypertensive medications use was reduced among patients with baseline hypertension, suggesting that improved fluid management may be helpful in managing hypertension. Analysis of changes in antihypertensive medication use in baseline hypertensive patients suggests that increases in antihypertensive medications were not causing SBP reduction. Patients who had antihypertensive medications decreased (Decrease group) had the largest drop in SBP, while the patients with an increase in antihypertensive medications (Increase group) experienced a rise in SBP. Additionally, antihypertensive medication use in dialysis patients has been controversial and may not be considered appropriate for all patients\(^6\). For instance, antihypertensive medications can interfere with compensatory vasoconstriction that maintains BP during rapid intravascular volume changes\(^{28}\). This may raise the risk of symptomatic intradialytic hypotension during HD. Thus, aiming to reduce antihypertensive medications in HD patients is warranted.

In baseline hypertensive patients, significant increases in dialysis treatment time, as well as adequacy and clearance were observed. Increased adequacy could be due to decreases in time when UF was reduced or set to minimum, thus allowing continuous treatment\(^{29}\). The increase in treatment time could contribute to improved clearance, fluid removal, and BP control\(^{30}\). Although the improvements in adequacy remained in the patients without prescribed treatment time increases, this quality improvement project substantiates the importance of longer treatment times.

This analysis has some limitations that should be considered. First, this was a single, clinic-wide, quality improvement project with no control group.
Second, data were collected under real-world clinic conditions, not as part of a controlled clinical study where only routinely measured clinical variables were available and missing data were possible. Also, the analysis of BV data through monthly averages may have masked changes within the monthly time frame. Finally, quality improvement project analyses were not adjusted for death or the presence of hypotensive-prone or -resistant patients. After initiation of this fluid management quality improvement project using BV monitoring, treatment times increased, dialysis adequacy and possibly nutritive status improved, pre- and post-HD SBP decreased, and the need for antihypertensive medications in baseline hypertensive patients was reduced.

## Conclusions

In summary, during this 12 month long fluid management ongoing quality improvement project, decreases in post-dialysis SBP and increases in adequacy and treatment time were observed. Patients with hypertension at Month 1 experienced reductions in pre-dialysis SBP and antihypertensive medications. Over the 12 month period, a decrease in post-HD SBP and increase in adequacy and treatment time were observed. After stratification by baseline hypertension, significant increases in the average dialysis treatment time, the average eKt/V, and the average OLC were observed. In addition, there were significant decreases in the pre- and post-HD SBP and phosphorous levels. The lowering of SBP was not associated with increased use of antihypertensive medications. Improving fluid management with BV monitoring should continue to be investigated in patients on hemodialysis.

## Transparency

### Declaration of funding

This quality improvement initiative is funded by the Renal Research Institute (RRI).

### Declaration of financial/other relationships

P.B. has disclosed that he is the Medical Director of Renal Research Institute, and owns stock in the company. L.H.F. and P.B.T. have disclosed that they are employees of Fresenius Medical Care. L.U., D.A.S., C.M., and P.Z. have disclosed that they are employees of Fresenius Medical Care. J.D.-B. has disclosed that he is a consultant/advisor to Fresenius Medical Care. L.U., D.A.S., C.M., and P.Z. have disclosed that they are employees of Fresenius Medical Care. L.U., D.A.S., C.M., and P.Z. have disclosed that they are employees of Fresenius Medical Care.

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Figure 2. Monthly changes in pre- and post-HD SBP in Baseline Hypertensive patients. Pre- and post-dialysis SBP in hypertensive groups are shown through Month 12. Values given in mmHg. Monthly average post-dialysis SBP is denoted by the filled diamond and the pre-dialysis SBP by the filled square.

Table 4. Blood pressure medication changes by change in pre-HD SBP in Baseline Hypertensive group.

| Pre-HD SBP Δ (n = 28) | Reduction 8 (29%) | Increase 3 (11%) | No change 7 (25%) | Variation* 10 (36%) |
|------------------------|------------------|-----------------|------------------|-------------------|
| Decrease (46%)         | 4                | 2               | 2                | 5                 |
| No Change (36%)        | 2                | 0               | 4                | 4                 |
| Increase (18%)         | 2                | 1               | 1                | 1                 |

*Patient had a change in anti-hypertension regimen; however, physician who reviewed the change indicated it was a switch without a clear increase or decrease.
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