Increased postdialysis systolic blood pressure is associated with extracellular overhydration in hemodialysis outpatients

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Recently, intradialytic hypertension was reported to be associated with increased mortality for hemodialysis patients. To determine whether volume status plays a role in dialysis-associated hypertension, we prospectively audited 531 patients that had volume assessments measured by multiple-frequency bioelectrical impedance during their midweek dialysis session. Mean pre- and postdialysis weights were 73.2 vs 71.7 kg, and systolic blood pressures (SBPs) 140.5 vs. 130.3 mm Hg, respectively. Patients were divided into groups based on a fall in SBP of 20 mm Hg or more (32%), an increased SBP of 10 mm Hg or more (18%), and a stable group (50%). There were no differences in patient demographics, dialysis prescriptions, predialysis weight, total body (TBW), and extracellular (ECW) and intracellular water (ICW). However, the change in weight was significantly less in the increased blood pressure group (1.01 kg vs. stable 1.65, and 1.7 hypotensive). The ratio of ECW to TBW was significantly higher in the increased blood pressure group, particularly post dialysis (39.1 vs. stable 38.7% and fall in blood pressure group 38.7%). ECW overhydration was significantly greater in the increased blood pressure group post dialysis (0.7 (0.17 to 1.1) vs. stable 0.39 (−0.2 to 0.95) and fall in blood pressure group 0.38 (−0.19 to 0.86) liter). We found that patients who had increased blood pressure post dialysis had greater hydration status, particularly ECW. Thus, patients who increase their blood pressure post dialysis should have review of target weight, consideration of lowering the post-dialysis weight, and may benefit from increasing dialysis session time or frequency.

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Although a fall in blood pressure remains the commonest complication associated with routine outpatient hemodialysis treatments,[1,2] a minority of patients become hypertensive either toward or at the end of dialysis or shortly after completion of the dialysis session. Although a recognized complication of hemodialysis,[3,4] it is only relatively recently that intradialytic hypertension has been recognized as an independent risk factor for both more frequent hospital admissions and also decreased patient survival.[5,6] The definition of intradialytic hypertension has varied over the years,[3–7] but most clinical studies now report intradialytic hypertension as an increase in systolic blood pressure (SBP) during dialysis of greater than 10 mm Hg above the predialysis blood pressure measurement.[5,6]

Intradialytic hypertension has been reported to occur in about 21% of hemodialysis sessions, affecting more than 15% of patients,[8] and it is more frequently reported in older patients, those prescribed more antihypertensive medications, and those with lower serum creatinine.[9] Although intravascular volume is typically reduced during dialysis, changes in relative blood volume do not necessarily closely mirror changes in blood pressure,[10] and this has led to the hypothesis that intradialytic hypertension is more likely to be due to changes in vascular tone.[11] The cause of intradialytic hypertension remains to be determined, with different authors speculating on increased renin and angiotensin release and sympathetic nervous system activation in response to ultrafiltration, elimination of antihypertensive medications in patients with established hypertension, increased viscosity and hematocrit following ultrafiltration, and high dialysate calcium concentrations.[3,4] However, as there is a link between sodium balance and hypertension in hemodialysis patients,[12,13] we speculated that patients with intradialytic hypertension could also potentially have an expanded extracellular volume to account for the rise in blood pressure during dialysis. We therefore reviewed the dialysis records of 531 patients who had volume assessments measured by multiple-frequency bioelectrical impedance to determine whether volume status had a role in dialysis-associated hypertension.

RESULTS

Multifrequency bioelectrical impedance assessments were made on 531 stable adult patients attending for their midweek hemodialysis session; the mean age was 60.3 ± 16.5 years, 62.0% were male, 37.3% were diabetic, 42.2% were Caucasoid, and the median dialysis vintage was 42.0 (23.7–48.5) months. Predialysis weight was 73.2 ± 18.0 kg, and postdialysis weight was 71.7 ± 17.7 kg. Predialysis SBP was 140.5 ± 26.5 mm Hg with a diastolic blood pressure of 71.7 ± 17.7 mm Hg, and postdialysis systolic pressure was 130.3 ± 26.3 mm Hg with a diastolic blood pressure of 71.8 ± 15.2 mm Hg. Predialysis hemoglobin was 112.6 ± 15.2 g/l, median glucose was 6.2 (5.2–8.3) mmol/l, serum albumin was 38.6 ± 6.2 g/l, and median C-reactive protein was 5 (2–12) mg/l.

A total of 67 patients were not included in the audit as bioimpedance was not performed, because 14 patients had pacemakers/defibrillators, 15 were unable to stand owing to amputations or active foot ulceration, 12 were recent starters, 6 had recent hospital in-patient stays, and the remaining 20 patients had a variety of metallic prosthetic implants—hips and knees—or were unable to stand. As such bioimpedance measurements were made on 89% of patients attending for their midweek dialysis session.

Patients were divided into three groups, those in whom the blood pressure decreased during dialysis by $\geqslant$20 mm Hg,[14] $n = 171$ (32.2%), those in whom the SBP increased by $\geqslant$10 mm Hg,[5] $n = 96$ (18.1%), and 264 patients (49.7%) in whom the SBP did not meet the definitions of intradialytic hypotension or hypertension, from here on termed the 'stable' group (Supplementary Figure online). These three groups did not differ in demographics, or cardiac history and medications (Supplementary Table S1 online), although those with a fall in blood pressure with dialysis were of an older dialysis vintage (46 (15–74) months) compared with both those with 'stable' (27 (9–64) months) and those with an increase in SBP post dialysis (23 (5–63.6) months), $P < 0.05$ (Supplementary Table S1 online); in addition, the 'stable' blood pressure group had fewer diabetics (30.7%) compared with the fall in SBP (45%) group and with the increased blood pressure group (41.7%). There were no differences in dialysis prescription (Supplementary Table S2 online).

A total of 17 nursing interventions were recorded during the dialysis sessions; 10 patients had their ultrafiltration rate reduced or stopped (six in the fall in blood pressure group and four in the stable group), and seven patients were given a bolus of intravenous fluid (two in the fall in blood pressure group and four in the stable group); the mean SBP for these patients was 111.2 ± 10.4 mm Hg.

Predialysis hemoglobin and serum biochemistries did not differ between the groups, nor did dialysate composition or dialysis modality (Supplementary Table S2 online). Similarly, there was no difference in the dialysate to serum sodium gradient, and also when corrected for glucose effect, or between the preserum and postserum sodium (Supplementary Table S2 online). Urea reduction ratios were marginally, but statistically significantly, greater in the stable cohort compared with those who increased their blood pressure post dialysis, 74.8 ± 7.2 vs. 71.4 ± 8.5% ($P = 0.032$), but there was no difference between the group with a fall in SBP with dialysis, 74.4 ± 7.1%.

Postdialysis SBP differed between the groups (Figure 1). However, the predialysis SBP was higher in those patients who were documented to have a fall in SBP of $\geqslant$20 mm Hg, and it was lower in those who had a rise in SBP of $\geqslant$10 mm Hg (Figure 1). Predialysis diastolic blood pressures showed a similar pattern to predialysis SBP, but the difference after dialysis was limited to those groups that had decreased and increased blood pressures post dialysis, respectively (Figure 2).

Neither weight, total body water (TBW), nor extracellular water (ECW) and intracellular water (ICW) differed between the groups before or after dialysis (Table 1). However, the change in absolute weight was less for the group in which blood pressure increased post dialysis (1.01 ± 1.2 vs. stable 1.65 ± 1.4, and 1.7 ± 1.0 fall in blood pressure group, $P < 0.05$), as was the percentage weight loss of 1.47 ± 1.5 for the group in which blood pressure increased post dialysis (2.3 ± 1.8 in the stable group and 2.3 ± 1.5 in the fall in blood pressure group, respectively, $P < 0.05$). The relative ratio of ECW to TBW was greater in those patients who had an increase in SBP post dialysis of $\geqslant$10 mm Hg (Table 1). Estimation of ECW overhydration was similarly greater for this group (Figure 3). A logistic regression model comparing patients in whom SBP increased post dialysis compared with patients with stable blood pressure or a fall in blood pressure showed that only ECW hydration status remained significant (β 0.382, s.e. 0.12, Wald 10.07 $P = 0.002$). This finding was supported by a sensitivity analysis (Supplementary Table S3 online). An additional multivariable multilevel regression random intercept model was analyzed with the outcome SBP, clustered within subjects, examining the effect of volume status in tertiles and the dialysis procedure adjusted for age, sex and diabetes. Patients in the highest ECW/TBW tertile

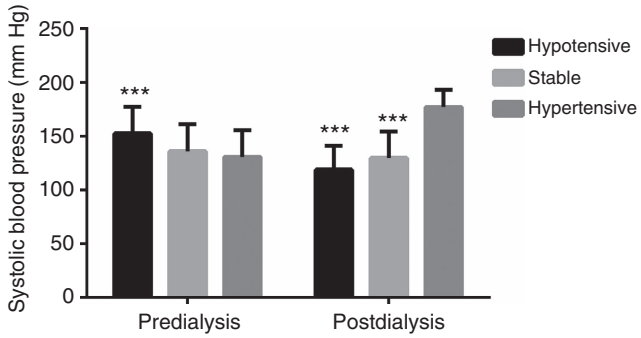

Figure 1 | Predialysis and postdialysis systolic blood pressure according to groupings. Patients with a fall in systolic blood pressure $\geqslant$20 mm Hg between predialysis and postdialysis systolic blood pressure recordings (hypotensive), patients with an increase in systolic blood pressure of $\geqslant$10 mm Hg (hypertensive), and those patients with systolic blood pressure change of $<$10 mm Hg to $-$19 mm Hg (stable). Values expressed as mean ± s.d. ***$P < 0.001$ vs. hypertensive group.