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Original Investigation

Effect of Fluid Management Guided by Bioimpedance Spectroscopy on Cardiovascular Parameters in Hemodialysis Patients: A Randomized Controlled Trial

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Background: Fluid overload is the main determinant of hypertension and left ventricular hypertrophy in hemodialysis patients. However, assessment of fluid overload can be difficult in clinical practice. We investigated whether objective measurement of fluid overload with bioimpedance spectroscopy is helpful in optimizing fluid status.

Study Design: Prospective, randomized, and controlled study.

Setting & Participants: 156 hemodialysis patients from 2 centers were randomly assigned to 2 groups.

Intervention: Dry weight was assessed by routine clinical practice and fluid overload was assessed by bioimpedance spectroscopy in both groups. In the intervention group (n = 78), fluid overload information was provided to treating physicians and used to adjust fluid removal during dialysis. In the control group (n = 78), fluid overload information was not provided to treating physicians and fluid removal during dialysis was adjusted according to usual clinical practice.

Outcomes: The primary outcome was regression of left ventricular mass index during a 1-year follow-up. Improvement in blood pressure and left atrial volume were the main secondary outcomes. Changes in arterial stiffness parameters were additional outcomes.

Measurements: Fluid overload was assessed twice monthly in the intervention group and every 3 months in the control group before the mid- or end-week hemodialysis session. Echocardiography, 48-hour ambulatory blood pressure measurement, and pulse wave analysis were performed at baseline and 12 months.

Results: Baseline fluid overload parameters in the intervention and control groups were 1.45 ± 1.11 (SD) and 1.44 ± 1.12 L, respectively ($P = 0.7$). Time-averaged fluid overload values significantly decreased in the intervention group (mean difference, −0.5 ± 0.8 L), but not in the control group (mean difference, 0.1 ± 1.2 L), and the mean difference between groups was −0.5 L (95% CI, −0.8 to −0.2; $P = 0.001$). Left ventricular mass index regressed from 131 ± 36 to 116 ± 29 g/m^2 ($P < 0.001$) in the intervention group, but not in the control group (121 ± 35 to 120 ± 30 g/m^2; $P = 0.9$); mean difference between groups was −10.2 g/m^2 (95% CI, −19.2 to −1.17 g/m^2; $P = 0.04$). In addition, values for left atrial volume index, blood pressure, and arterial stiffness parameters decreased in the intervention group, but not in the control group.

Limitations: Ambulatory blood pressure data were not available for all patients.

Conclusions: Assessment of fluid overload with bioimpedance spectroscopy provides better management of fluid status, leading to regression of left ventricular mass index, decrease in blood pressure, and improvement in arterial stiffness.

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INDEX WORDS: Bioimpedance spectroscopy; hemodialysis; hypervolemia; fluid overload; left ventricular hypertrophy.

Editorial, p. 861

The excessive mortality of hemodialysis (HD) patients, particularly from cardiovascular events, is related mostly to hypertension and cardiac damage.[1] Most studies show that hypertension persists despite antihypertensive drug use, whereas left ventricular hypertrophy (LVH) is not mitigated and often worsens throughout the renal replacement therapy. Some authors have used the term "natural history" of heart disease in dialysis, suggesting that deterioration inevitably is linked to this procedure.[2]

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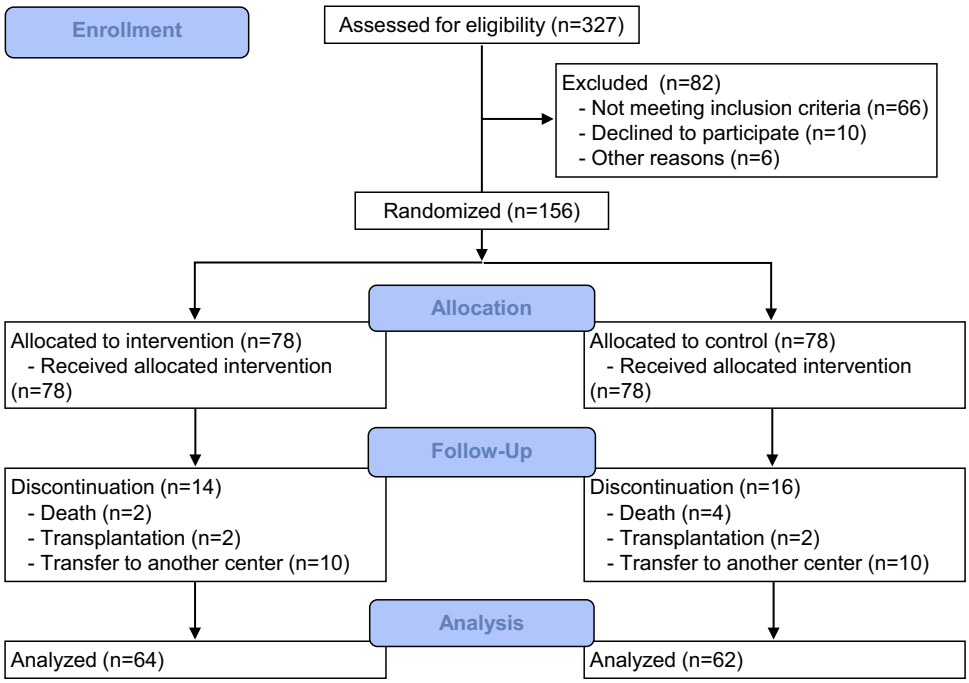

Figure 1. Patient flow in the study.

In sharp contrast, other studies[3,4] have shown that a strict volume control strategy decreases blood pressure (BP) without drugs, causes regression of LVH, and prolongs survival. This suggests that volume control is insufficient in most HD centers, although treating physicians may consider that "dry weight" of their patients has been achieved. There has been no easily applicable method to determine excess extracellular water and consequently assess dry weight.[5] Thus, it has been necessary to clinically define dry weight by trial and error and several indirect methods. In addition to poor control of hypertension, intradialytic hypotension has continued to be a problem,[6] particularly in elderly and cardiovascularly compromised patients.[7]

Recently, devices to assess fluid overload objectively by bioimpedance spectroscopy have become available. The aim of the present study was to assess the impact of bioimpedance spectroscopy−guided fluid management on cardiac condition and BP. Therefore, we conducted a randomized controlled trial to compare results of bioimpedance spectroscopy-guided management with conventional therapy in 2 groups of patients from the same HD units.

METHODS

Patient Selection

Study participants were recruited from patients on maintenance HD treated in 2 dialysis centers operated by Fresenius Medical Care in Bursa, Turkey, where 327 patients were being treated. Patients who were willing to participate in the study with written informed consent, older than 18 years, and on maintenance HD therapy scheduled thrice weekly (12 hours weekly) for 3 months or longer were included. Exclusion criteria were the presence of a pacemaker or defibrillator, artificial joints or pins, amputation, permanent or temporary catheters, being scheduled for living donor kidney transplantation, presence of serious life-limiting comorbid situations (eg, malignancy, uncontrollable infection, and end-stage cardiac, pulmonary, or hepatic disease), being pregnant, or lactating. After enrollment of 245 individuals who met the study criteria, 156 randomly selected prevalent HD patients were randomly assigned to the intervention (n = 78) and control groups (n = 78; Fig 1).

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and in compliance with the Good Clinical Practice Guidelines. All patients were seen by their physician every month. Additional visits were scheduled if symptoms or intolerance were observed.

Treatment Protocol

Intervention Group

Fluid overload was measured objectively with bioimpedance spectroscopy (Body Composition Monitor; Fresenius Medical Care, Germany) twice monthly before the HD session. Measurements were performed after a short interdialytic interval (mid- or end-week dialysis session) to exclude the influence of additional predialysis fluid overload after the long interval. Patients are exposed to different amounts of fluid overload during the interdialytic period even if normal fluid status (normohydration) is achieved postdialysis. Therefore, time-averaged fluid overload (TAFO) was used as a more representative measure of patients' fluid status.

TAFO was calculated based on the measured predialysis fluid overload (FO_{pre}) and interdialytic weight gain (IDWG): TAFO = FO_{pre} – IDWG/2 (Fig S1, available as online supplementary material). We aimed to achieve time-averaged fluid overload of 0 L in the intervention group. Time-averaged fluid overload was transformed into the target postdialysis weight (TPDW) to facilitate the communication in the dialysis unit: TPDW = (predialysis weight – TAFO). Therefore, if we put it another way, we aimed to reach