The long-term effects of dietary sodium restriction on clinical outcomes in patients with heart failure. The SODIUM-HF (Study of Dietary Intervention Under 100 mmol in Heart Failure): A pilot study

Eloisa Colin-Ramirez, BSc, PhD, [a,c] Finlay A. McAlister, MD, MSc, [b,c] Yinggan Zheng, MA, MEd, [c] Sangita Sharma, PhD, [a] Paul W. Armstrong, MD, [a,c,d] and Justin A. Ezekowitz, MBBCh, MSc [a,c,d,e] *Edmonton, Canada*

Aims To determine the feasibility of conducting a randomized controlled trial comparing a low-sodium to a moderate-sodium diet in heart failure (HF) patients.

Methods and Results Patients with HF (New York Heart Association classes II-III) were randomized to low (1500 mg/d) or moderate-sodium (2300 mg/d) diet. Dietary intake was evaluated using 3-day food records. The end points were changes in quality of life as measured by the Kansas City Cardiomyopathy Questionnaire (KCCQ) scores and B-type natriuretic peptide (BNP) levels from baseline to 6 months of follow-up presented as medians [25th, 75th percentiles]. Thirty-eight patients were enrolled (19/group). After 6 months, median sodium intake declined from 2137 to 1398 mg/d in the low-sodium and from 2678 to 1461 mg/d in the moderate-sodium diet group. Median BNP levels in the low-sodium diet group declined (216-71 pg/mL, $P = .006$), whereas in the moderate-sodium diet group, there was no change in BNP (171-188 pg/mL, $P = .7$; $P = .17$ between groups). For 6 months, median KCCQ clinical score increased in both groups (63-75 [$P = .006$] in the low-sodium diet group and 66-73 [$P = .07$] in the moderate-sodium group; $P = .4$ between groups). At 6 months, a post hoc analysis based on the dietary sodium intake achieved (> or ≤1500 mg/d) in all patients showed an association between a sodium intake ≤1500 mg/d and improvement in BNP levels and KCCQ scores.

Conclusions A dietary intervention restricting sodium intake was feasible, and achievement of this sodium goal was associated with lower BNP levels and improved quality of life in patients with HF. (Am Heart J 2015;169:274-281.e1.)

Chronic heart failure (HF) remains a major and growing public health problem. Approximately 1% to 2% of the adult population in developed countries have HF, with the prevalence rising to ≥10% among persons 70 years or older.[1] Despite advances in detection and treatment, HF carries a 5-year mortality rate of ~50% after diagnosis[2] and between 20% and 30% per year attend an emergency department or get hospitalized.[3] Pharmacologic and nonpharmacologic interventions that can further reduce morbidity and mortality for this important public health concern are clearly needed.

Heart failure is associated with neurohormonal activation and abnormalities in autonomic control that lead to sodium and water retention. Recognizing the importance of sodium balance in HF, it has been presumed that reducing dietary sodium intake in HF is a useful intervention.[4] However, observational[5-8] and experimental[9-17] studies evaluating the effects of sodium restriction in patients with HF have shown mixed results.[18] Accordingly, there is a lack of consensus among guidelines on the recommended level of dietary sodium intake for patients with chronic HF.[1,19-22]

We hypothesized that patients with HF after a low-sodium diet will have a reduction in B-type natriuretic peptide (BNP) levels and improvement in quality of life when compared with patients after a moderate-sodium diet. Accordingly, the *main objective* of this pilot study was to determine the feasibility of conducting a randomized controlled trial (RCT) comparing a low-sodium diet to a moderate-sodium diet. Secondarily, we explored whether there would be any changes in quality

From the [a]Medicine Department, University of Alberta, Edmonton, Canada, [b]Division of General Internal Medicine, University of Alberta, Edmonton, Canada, [c]Canadian VIGOUR Centre at the University of Alberta, Edmonton, Canada, [d]Division of Cardiology, University of Alberta, Edmonton, Canada, and [e]Heart Function Clinic, Division of Cardiology, University of Alberta, Edmonton, Canada.

Clinical Trial Identifier: Clinicaltrials.gov Identifier: NCT01480401.

Submitted September 12, 2014; accepted November 11, 2014.

Reprint requests: Justin A. Ezekowitz, MBBCh MSc, University of Alberta Hospital, 2C2 WMC, 8440-112 St, Edmonton, Alberta, Canada.

E-mail: jae2@ualberta.ca

0002-8703

http://dx.doi.org/10.1016/j.ahj.2014.11.013

of life or BNP levels from pursuing a low-sodium diet in patients with chronic HF.

Methods

Study design

A pilot, open-label, blinded adjudicated end point, RCT was conducted to evaluate the efficacy of a low-sodium (65 mmol or 1500 mg daily) compared with a moderate-sodium (100 mmol or 2300 mg daily) diet on quality of life and BNP levels after 6 months of follow-up in ambulatory patients with chronic HF.

Patients were included if they were 18 years or older and willing/able to sign informed consent, with confirmed diagnosis of HF (both reduced and preserved systolic function), New York Heart Association (NYHA) classes II-III, and on optimally tolerated medical therapy according to Canadian Cardiovascular Society (CCS) guidelines.[23] Patients were excluded if they had a serum sodium <130 mmol/L, glomerular filtration rate <20 mL/min, uncontrolled thyroid disorder, end-stage hepatic failure, a cardiac event within the prior month (implantation of a defibrillator or resynchronization pacemaker, a revascularization procedure or hospitalization due cardiovascular causes), uncontrolled atrial fibrillation (resting heart rate >90 beats/min), active malignancy with an expected life expectancy <2 years, or another comorbid condition or situation which, in the opinion of the investigator, could preclude compliance with the protocol. Patients were recruited from a specialty HF clinic, the Heart Function Clinic of the Mazankowski Alberta Heart Institute in Edmonton, Canada.

The study was approved by the Health Research Ethics Board of the University of Alberta, and all the patients provided written informed consent to participate in this study.

Randomization, data collection, and treatment allocation

After providing written informed consent and having undergone baseline assessments, patients were randomly assigned by the research dietitian to either the low or moderate sodium group (randomization details provided as online Appendix Supplementary material). Dietary treatment was concealed from the clinician in charge of performing evaluations. Study data were collected and managed using REDCap electronic data capture tools.[24]

Dietary intervention

The levels of sodium restriction were chosen to reflect clinical practice and guideline recommendations.[5,21] Regardless of the level of sodium restriction (<2300 or <1500 mg/d), participants in both groups were prescribed a normocaloric diet with the following energy distribution as percentage of daily energy intake—carbohydrates, 50%-55%; protein, 15%-20%; fat, 25%-30%; and saturated fat, <7%—consistent with the guidelines for a cardiovascular healthy diet in order to standardize macronutrients intake between groups.[25] Patients in both groups were encouraged to prefer homemade food and were provided with dietary recommendations (online Appendix Supplementary material) and a set of six daily sample menus according to their energy requirements, energy distribution, and targeted sodium intake.

Patients in both groups received conventional pharmacologic and nonpharmacologic treatment of HF, according to current CCS guidelines,[23] and were asked to follow the recommendations for fluid restriction provided by the clinician as per clinical practice.

Assessments and follow-up

Dietary, clinical, biochemical, and quality of life evaluations were performed at baseline and repeated at 6 months. Dietary intake was evaluated by using a 3-day food record as described below. This evaluation was also repeated at 3 months to reinforce adherence to the dietary treatment. In addition, patients in both groups were contacted by telephone by the research dietitian every month to reinforce dietary compliance.

Dietary intake. Patients were asked to complete a 3-day food record during the previous week to each clinical visit (baseline, 3 months, and 6 months), including 2 weekdays and 1 weekend day (details provided as online Appendix Supplementary material). Food record assessment of sodium intake has been validated against urinary sodium excretion in healthy individuals and in patients with hypertension.[26,27] These 2 methods were also found to be correlated in patients with cardiac disease without HF ($r = 0.624$, $P < .001$) and in HF patients who were not taking a loop diuretic ($r = 0.678$, $P < .001$), but not in those who were taking loop diuretics ($r = 0.132$, $P = .312$), suggesting that the food record method is a more appropriate method for sodium intake assessment in HF patients on a diuretic therapy.[28] The 3-day food record method has been previously used in populations with HF for assessing sodium and overall dietary intake[5,29–31]

Clinical data. Presence of symptoms and signs of HF and NYHA class (as well as comorbidities) were evaluated during the medical interview.

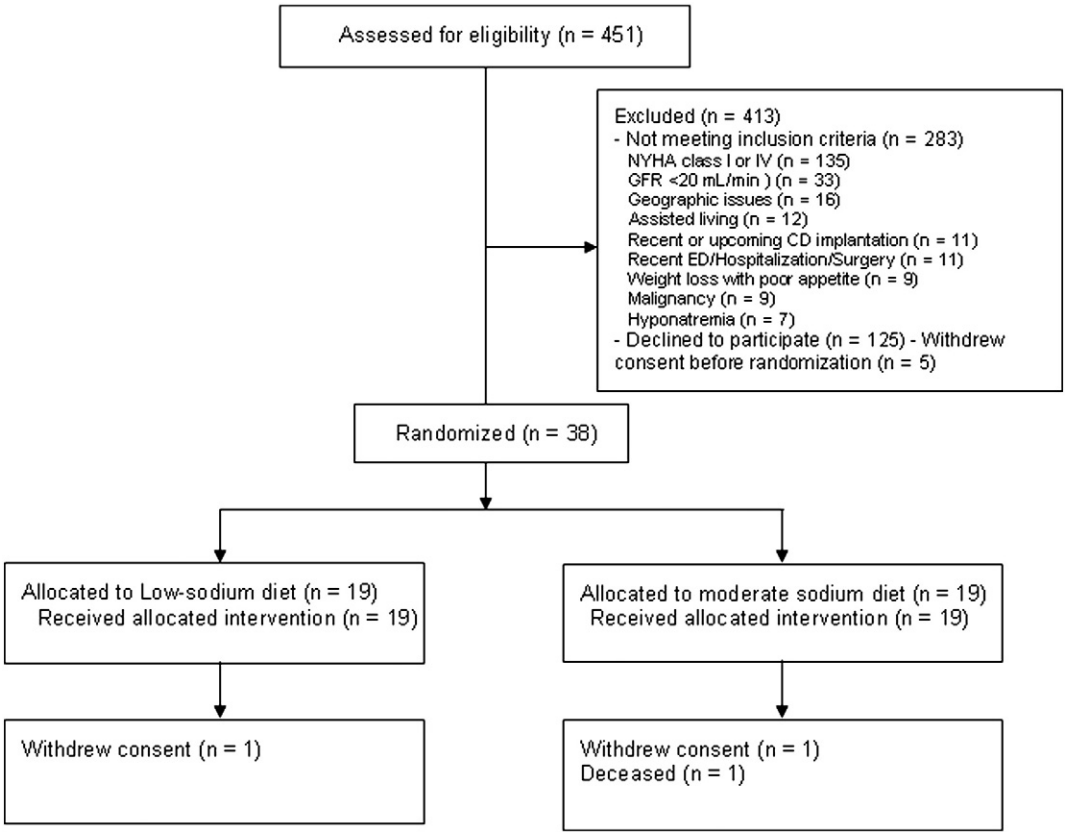
Biochemical. Nonfasting blood samples were collected to determine serum levels of electrolytes, albumin, creatinine, and hemoglobin, as well as plasma levels of BNP (Biosite assay; Alere, San Diego, California; measurable range 5.0-1300 ng/L).

Quality of life. The Kansas City Cardiomyopathy Questionnaire (KCCQ) was used, with a higher score indicating better health-related quality of life.[32] A difference of 5 points in the overall score is considered to be clinically meaningful.[33]

Statistical analysis

Categorical variables are reported as percentages and continuous variables are presented as medians with 25th and 75th percentiles. χ^2 Test was used to measure

Figure 1



Study cohort.

between-group differences for categorical variables, and Wilcoxon rank sum test was used for continuous variables. To test differences over time (within group), McNemar test was applied for categorical variables and Wilcoxon signed rank test was used for continuous variables.

Because of the significant reduction in sodium intake observed at follow-up in both the low and moderate-sodium diet groups, a post hoc analysis was performed to test the robustness of the association between a low sodium intake and improvement in BNP levels and quality of life. For this analysis, all patients were divided into 2 groups according to the dietary sodium intake achieved at the end of the follow-up (split at 1500 mg/d), regardless of randomized treatment group.

All statistical tests were 2 sided with a P value less than .05 considered as statistically significant. Statistical analyses were performed using SAS (version 9.3; Cary, NC).

The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the manuscript and its final contents.

Results

A total of 451 patients underwent screening between May and December 2012, of which 38 patients were enrolled. Most (63%) of patients screened did not meet the inclusion criteria. Being in NYHA class I or IV was the main reason why patients did not qualify for this study. During follow-up, 2 patients dropped out (one in each group) and 1 died (in the moderate-sodium diet group) (Figure 1). Of the overall study population, 95% (n = 37) was white, 3% (n = 1) was Afro-American, and 3% (n = 1) was South Asian. Baseline characteristics are shown in Table I. Patients in both groups did not differ significantly, and most of the patients were NYHA class II. There were no differences between groups in the baseline use of cardiac medications.

Dietary intake

At the end of the 6 months of follow-up, median of sodium intake dropped significantly in both groups, from 2137 to 1398 mg/d (median change, 931 [251, 1903], P =

Table I. Patient characteristics according to randomized treatment arm

Characteristics	Overall (n = 38)	Low-sodium diet (n = 19)	Moderate-sodium diet (n = 19)	P*
Demographics, history, and physical examination				
Age (y)	65.5 (56.3-72.1)	66.1 (58.0-71.4)	63.9 (51.6-76.9)	.98
Female (%)	52.6	42.1	63.2	.20
NYHA class (%)				.29
II	89.5	84.2	94.7	
III	10.5	15.8	5.3	
Ischemic etiology (%)	31.6	36.8	26.3	.49
Atrial fibrillation/flutter (%)	48.7	52.6	44.4	.62
Cerebrovascular disease (%)	7.9	5.3	10.5	.55
Diabetes mellitus (%)	31.6	21.1	42.1	.16
BMI (kg/m^2) categories				.65
Underweight <18.5	0	0	0	
Normal weight 18.5-24.9	15.8	21.1	10.5	
Overweight 25-29.9	26.3	26.3	26.3	
Obesity ≥30	57.9	52.6	63.2	
Laboratory and echocardiographic values				
Sodium (mmol/L)	139 (137-140)	139 (138-141)	138 (136-140)	.31
Potassium (mmol/L)	4.2 (3.9-4.6)	4.2 (3.8-4.6)	4.2 (3.9-4.6)	.53
Albumin (g/L)	41.5 (38.0-43.0)	42.0 (38.0-43.0)	41.0 (39.0-43.0)	.95
Creatinine (μmol/L)	98 (75-130)	104 (75-138)	93 (75-118)	.59
Hemoglobin (g/L)	134 (115-142)	134 (115-143)	134 (114-141)	.86
Ejection fraction (%)	42.0 (25.0-50.5)	46.5 (30.0-59.5)	34.5 (24.0-45.0)	.06
Cardiac medications				
ACEi or ARB (%)	89.5	89.5	89.5	1.00
β-Blockers (%)	94.7	94.7	94.7	1.00
MRA (%)	55.3	47.4	63.2	.33
Loop diuretics (%)	81.6	89.5	73.7	.21
Non-loop diuretics (%)	18.4	15.8	21.1	1.00
Antiplatelet (%)	100.0	100.0	100.0	1.00
Anticoagulants (%)	44.7	47.4	42.1	.74

Abbreviations: *BMI*, Body mass index; *SBP*, systolic blood pressure; *DBP*, diastolic blood pressure; *ACE inhibitors*, angiotensin-converting-enzyme inhibitor; *ARB*, angiotensin receptor blockers; *MRA*, mineralocorticoid receptor antagonist; *ASA*, acetyl salicylic acid.
Antiarrhythmic drugs include amidarone and sotalol; loop diuretics includes only furosemide; non–loop diuretics includes metalozone and thiazide.
Values are medians (25-75 percentile) unless otherwise stated.
*χ^2 Test was used for categorical variable; Wilcoxon rank sum test was used for continuous variables.

.001) in the low-sodium diet group and from 2678 to 1461 mg/d (median change, 898 [173, 1337], $P = .002$) in the moderate-sodium diet group (Table II). There was no difference between the 2 groups for the change of sodium intake over the 6 months (931 vs 898, $P = .50$). No significant changes in energy intake or total fluid intake were seen in either group (Table II).

B-type natriuretic peptide levels

Median BNP levels decreased for 6 months in the low-sodium diet group (216-71 pg/mL, with a median change of 51 pg/mL [−2, 331]; $P = .006$), whereas no significant changes were found in the moderate-sodium diet group (171-188 pg/mL, with median change of 36 pg/mL [−51, 62]; $P = .67$) (Table II). No significant difference was found for comparison of changes between groups ($P = .18$).

Quality of life

For 6 months, median KCCQ clinical score increased in the low-sodium diet group (63-75 points, with median change of 9 [2, 15]; $P = .006$) and trended to increase in the moderate-sodium group (66-73 points, with median change of 6 [−1, 15], $P = .07$; $P = .41$ between groups) (Table II). KCCQ overall scores followed a similar pattern to the clinical score (60-65 points, with a median change of 6 [0.5, 22], $P = .04$, for low-sodium group; 66-72 points, with median change of 5 [−3, 15], $P = .07$, for moderate group; $P = .44$ between groups).

Other clinical measures

At the end of follow-up, there was no significant difference in NYHA class between moderate- and low-sodium groups ($P = .87$). Creatinine levels increased at 6 months in the moderate-sodium diet group but not in the low-sodium group (Table II). No significant changes were found for body mass index, systolic blood pressure, heart rate, the use and dose of loop diuretics and frequency of dyspnea, peripheral edema, and fatigue from baseline to 6 months in either group (data not shown).

Post hoc analysis

When patients were reclassified according to the sodium intake achieved at the end of follow-up, there were no differences in distribution by sex and baseline

Table II. Changes at 6 months according to randomized treatment group

	Low-sodium diet (n = 19)			Moderate sodium diet (n = 19)		
Characteristics	**Baseline**	**6 mo**	***P*** *	**Baseline**	**6 mo**	***P*** *
Energy (kcal/d)	1525 (1251-2410)	1402 (1274-2034)	.18	1684 (1369-1891)	1397 (1252-1590)	.10
Sodium intake (mg/d)	2137 (1304-3118)	1398 (1090-2060)	.002	2678 (1797-3018)	1461 (1086-1765)	.001
Fluid (mL/d)	1638 (1483-2204)	1493 (1203-2120)	.13	1650 (1370-2070)	1670 (1290-2089)	.59
NYHA class (%)						
I	0	16.7	<.001	0	22.2	.003
II	84.2	61.1	.06	94.7	66.7	.003
III	15.8	22.2	.01	5.3	11.1	<.001
Creatinine (μmol/L)	104 (75-138)	110.5 (92.5-133)	.70	93 (75-118)	106.5 (78-114)	.03
BNP (pg/mL)	216 (25-670)	71 (39-222)	.006	171 (100-558)	188 (69-410)	.67
KCCQ clinical summary score	62.8 (41.2-72.4)	75.3 (61.5-87.5)	.006	66.4 (55.2-77.1)	72.9 (67.7-85.4)	.07
KCCQ overall summary score	59.6 (39.1-73.2)	64.6 (50.3-86.1)	.04	65.5 (47.7-82.3)	72.4 (63.8-86.3)	.07

*Wilcoxon signed rank test for continuous variables and McNemar test for categorical variables to test changes within groups.

Table III. Changes at 6 months according to dietary sodium intake achieved

	Na intake ≤1500 mg/d at 6 mo (n = 21)			Na intake >1500 mg/d at 6 mo (n = 14)			
Characteristics	**Baseline**	**6 mo**	***P*†**	**Baseline**	**6 mo**	***P*†**	***P****
Sodium intake (mg/d)	2354 (1391-3042)	1115 (921-1386)	<.001	2487 (2027-2927)	2082 (1865-2373)	.10	.04
Fluid intake (mL/d)	1560 (1370-1822)	1620 (1240-2089)	.60	1923 (1567-2390)	1656 (1290-2242)	.17	.07
NYHA class (%)							.08
I	0	23.8	.003	0	14.3	.004	
II	90.5	71.4	.002	92.9	50.0	.07	
III	9.5	4.8	<.001	7.1	35.7	.10	
Creatinine	108 (88-131)	112 (100-133)	.13	94.5 (66-128)	96 (73-109)	.25	.93
BNP (pg/mL)	199 (100-689)	118 (64-256)	.01	176 (36-366)	108 (39-259)	.72	.08
KCCQ clinical summary score	63.0 (53.7-83.3)	77.1 (67.2-87.5)	.003	68.5 (55.2-76.0)	68.8 (63.5-85.9)	.18	.08
KCCQ overall score	60.7 (44.8-77.1)	74.0 (63.5-88.8)	.007	62.2 (54.2-78.7)	64.6 (51.3-82.3)	.34	.16

*Wilcoxon rank sum test for comparison of changes between groups.
†Wilcoxon signed rank test for continuous variables and McNemar test for categorical variables to test changes within groups.

age and ejection fraction between groups (data not shown). Patients with an average daily sodium intake ≤1500 mg/d at 6 months showed a significant reduction in BNP and improvement in the KCCQ clinical and overall scores. Conversely, the group of patients with a sodium intake >1500 mg/d at 6 months did not show significant changes from baseline to 6 months in BNP levels or KCCQ overall and clinical scores (Table III and Figures 2–4). Also, the proportion of patients that showed an improvement in NYHA class tended to be greater in the low-sodium than the moderate-sodium group (P = .08). Other results, including fluid intake and loop diuretic dose, did not differ significantly at follow-up between and within groups (data not shown).

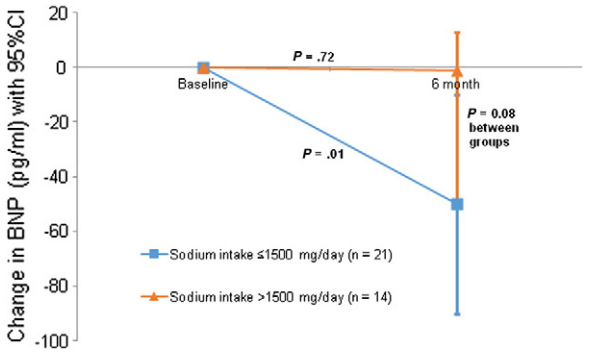
Discussion

Dietary sodium reduction has been proposed and supported by multiple guidelines, yet it is based on little high-quality evidence. In this pilot study, we showed that dietary sodium reduction in HF is feasible when an individualized and structured meal plan with close telephone follow-up is provided to patients.

The median dietary sodium intake at baseline was 2137 and 2678 mg/d in the low- and moderate-sodium group respectively, and it dropped to less than 1500 mg/d after 6 months of dietary treatment in both groups. The significant reduction in sodium intake observed in both groups at the end of follow-up may be explained, in part, by the use of an interventional approach with close follow-up in both groups. Previous RCTs on sodium reduction in HF that have used an individualized dietary counseling approach also showed a significant reduction in sodium intake to less than 2300 mg/d after 3 (30) or 6 (10, 31) months of follow-up, as determined by either 24-hour urinary sodium excretion[10] or 3-day food diaries.[30,31]

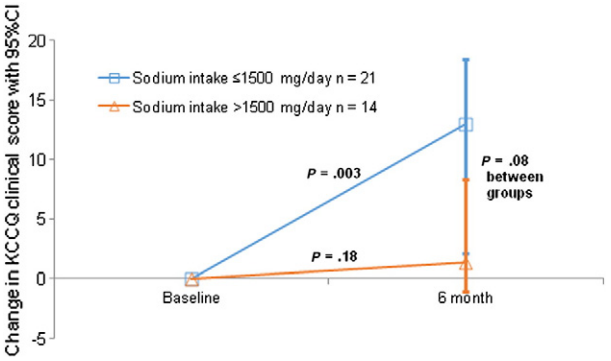
Interventional studies testing the effects of sodium restriction on clinical outcomes in HF have also been conducted. A 12-month RCT in 203 HF patients[11]

Figure 2



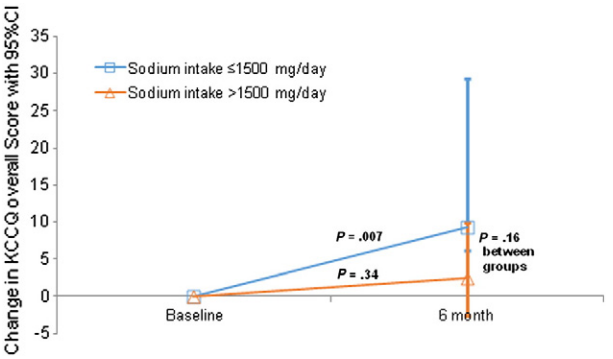
Change in BNP over time by achieved dietary sodium intake (> or ≤1500 mg/d). Within ≤1500 mg/d group: median change −50 (−272, −10), *P* = .01; within >1500 mg/d group: median change −1 (−51, 14), *P* = .72. Between groups, *P* = .08.

Figure 3



Change in KCCQ clinical score by achieved dietary sodium intake (> or ≤1500 mg/d). Within ≤1500 mg/d group: median change 13.02 (2.09, 18.44), *P* = .003; within >1500 mg/d group: median change 1.36 (−1.04, 8.33), *P* = .18. Between groups, *P* = .08.

Figure 4



Change in KCCQ overall score over time with dietary sodium intake (> or ≤1500 mg/d). Within ≤1500 mg/d group: median change 9.37 (3.12, 20.06), *P* = .007; within >1500 mg/d group: median change 2.48 (−2.61, 7.46), *P* = .34. Between groups, *P* = .16.

reported trends toward fewer readmissions (11.1% vs 15.7%, *P* = .3) and higher 12-month survival (93.7% vs 88.1%, *P* = .2) in the intervention group (target sodium intake <2400 mg/d) compared with controls (usual dietary recommendations for sodium restriction). Conversely, the 3 largest RCTs[14–16] on sodium restriction in HF showed that a low-sodium diet (80 mmol [1800 mg] sodium/d) was associated with higher mortality and readmission rates compared with a moderate-sodium diet (120 mmol [2800 mg] sodium/d). Confounding the interpretation of these latter 3 RCTs is that patients were also prescribed a high dose of loop diuretics (250-1000 mg of furosemide daily) and a 1-L fluid restriction. It is possible that patients following the low-sodium diet were hypovolemic in these trials as a result of this treatment combination. A meta-analysis (subsequently retracted due to concerns related to the validity of the data)[34,35] of these and other trials (6 RCT, n = 2747 patients) conducted by the same research group concluded that compared with a normal sodium diet (2,800 mg/d), a low-sodium diet (1,800 mg/d) significantly increased all cause mortality (relative risk [RR] 1.95, 95% CI 1.66-2.29), sudden death (RR 1.72, 95% CI 1.21-to 2.44), death due to HF (RR 2.23, 95% CI 1.77-2.81), and HF readmissions (RR 2.10, 95% CI 1.67-2.64) in patients with systolic HF.

In this pilot, although reductions in dietary sodium intake were observed in both study groups, greater BNP reduction was seen in the low-sodium group, possibly related to the variability in individual BNP reductions and the small sample size. Because of this issue, we further explored the robustness of the association between an achieved sodium intake less than 1500 mg/d and changes in BNP as stated in the post hoc analysis. Results of this analysis showed an improvement in quality of life and BNP levels (a biomarker of volume overload and surrogate prognostic marker in HF[36,37]) among patients who achieved a sodium intake less than 1500 mg/d, suggesting that the recent American Heart Association[38] recommendation of 1500 mg/d sodium for the general population may also be applicable for patients with HF. However, larger RCTs with clinical outcomes as primary end points are required to support this recommendation and confirm a better prognosis associated to less sodium intake in patients with HF.

In this pilot, the average sodium intake achieved at the end of the follow-up in both groups suggests that using a structured dietary intervention with close follow-up to target moderate sodium intake (2300 mg/d) may lead, in some cases, to a greater reduction in sodium intake than expected. In order to ensure that the intervention leads to more meaningful differences in sodium intake between groups, the SODIUM-HF trial (SODIUM-HF; clinicaltrials.

gov NCT02012179) is using the same dietary strategies used in this pilot to counsel patients in the low-sodium diet group. However, the usual care group is receiving usual dietary recommendation for sodium restriction and follow-up as provided during routine clinical practice and supported by the Canadian HF guidelines. This ongoing multicenter trial is expected to provide definite results on the effects of sodium restriction in HF patients and develop evidence-based guideline for sodium restriction in this patient population.

Limitations

This is a pilot trial, and therefore, it included a small sample size. Second, although the 3-day food record has the potential for recall bias and is not considered to be the criterion standard for assessing sodium intake in healthy populations, it is an accurate method particularly in HF patients who are taking loop diuretics (which distort urinary sodium excretion measurements).[28] Third, these results deserve exploration in other ethic groups because 95% of this study population was white. Finally, although an achieved sodium intake of <1500 mg/d was associated with lower BNP levels and greater improvements in quality of life, this cannot be considered proof of causation because patients who achieved lower sodium intakes may well have also been more adherent with prescribed medications, follow-up, and other lifestyle interventions that influence prognosis.

Conclusion

The dietary intervention in this study was feasible and effective in reducing sodium intake in patients with HF. In addition, an achieved sodium intake less than 1500 mg/d was associated with reduced BNP levels, a surrogate prognostic marker, and improved quality of life in ambulatory patients with HF on optimal medical treatment.

Acknowledgements

We are indebted to the staff and patients of the Heart Function Clinic; Elizabeth Woo, RD; and Quentin Kushnerik, RN, for making this possible.

Disclosures

The SODIUM-HF Pilot was funded by a University Hospital Foundation (Edmonton, Canada) grant. E.C.R. is funded by a postdoctoral fellowship from Alberta Innovates–Health Solutions (Edmonton, Canada) and the National Council of Science and Technology (CONACYT), Mexico. F.M.A. holds the Capital Health Chair in Cardiology Outcomes Research and an AIHS Senior Health Scholar Award. J.A.E. receives salary support from Alberta Innovates–Health Solutions.

Conflict of interest/disclosures: None declared.

References

1. McMurray J, Adamopoulos S, Anker SD, et al. ESC guidelines for the diagnosis and treatment of acute and chronic heart failure 2012. The Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC. Eur J Heart Fail 2012;14:803-69.
2. Roger VL, Go AS, Lloyd-Jones DM, et al. Heart disease and stroke statistics—2011 update: a report from the American Heart Association. Circulation 2011;123(4):e18-209.
3. Ezekowitz JA, Kaul P, Bakal JA, et al. Trends in heart failure care: has the incident diagnosis of heart failure shifted from the hospital to the emergency department and outpatient clinics? Eur J Heart Fail 2011;13(2):142-7.
4. Beich KR, Yancy C. The heart failure and sodium restriction controversy: challenging conventional practice. Nutr Clin Pract 2008;23(5):477-86.
5. Arcand J, Ivanov J, Sasson A, et al. A high-sodium diet is associated with acute decompensated heart failure in ambulatory heart failure patients: a prospective follow-up study. Am J Clin Nutr 2011;93(2):332-7.
6. Bonfils PK, Damgaard M, Taskiran M, et al. Impact of diuretic treatment and sodium intake on plasma volume in patients with compensated systolic heart failure. Eur J Heart Fail 2010;12:995-1001.
7. Lennie TA, Song EK, Wu JR, et al. Three gram sodium intake is associated with longer event-free survival only in patients with advanced heart failure. J Card Fail 2011;17(4):325-30.
8. Son YJ, Lee Y, Song EK. Adherence to a sodium-restricted diet is associated with lower symptom burden and longer cardiac event-free survival in patients with heart failure. J Clin Nurs 2011;20(21–22):3029-38.
9. Alvelos M, Ferreira A, Bettencourt P, et al. The effect of dietary sodium restriction on neurohumoral activity and renal dopaminergic response in patients with heart failure. Eur J Heart Fail 2004;6(5):593-9.
10. Colin E, Castillo L, Orea A, et al. Effects of a nutritional intervention on body composition, clinical status and quality of life in patients with heart failure. Nutrition 2004;20(10):890-5.
11. Colin E, Castillo L, Orea A, et al. Impact of a sodium and fluid restricted diet on clinical status in heart failure patients. Rev Chil Nutr 2010;37(4):427-37.
12. Damgaard M, Norsk P, Gustafsson F, et al. Hemodynamic and neuroendocrine responses to changes in sodium intake in compensated heart failure. Am J Physiol Regul Integr Comp Physiol 2006;290(5):R1294-301.
13. Nakasato M, Strunk CM, Guimarães G, et al. Is the low-sodium diet actually indicated for all patients with stable heart failure? Arq Bras Cardiol 2010;94(1):86-94.
14. Parrinello G, Di Pasquale P, Licata G, et al. Long-term effects of dietary sodium intake on cytokines and neurohormonal activation in patients with recently compensated congestive heart failure. J Card Fail 2009;15(10):864-73.
15. Paterna S, Gaspare P, Fasullo S, et al. Normal-sodium diet compared with low-sodium diet in compensated congestive heart failure: is sodium an old enemy or a new friend? Clin Sci 2008;114(3):221-30.
16. Paterna S, Parrinello G, Cannizzaro S, et al. Medium term effects of different dosage of diuretic, sodium, and fluid administration on neurohormonal and clinical outcome in patients with recently compensated heart failure. Am J Cardiol 2009;103(1):93-102.
17. Philipson H, Ekman I, Forslund HB, et al. Salt and fluid restriction is effective in patients with chronic heart failure. Eur J Heart Fail 2013;15(11):1304-10.

18. Gupta D, Georgiopoulou V, Kalogeropoulos A, et al. Dietary sodium intake in heart failure. Circulation 2012;126:479-85.
19. Hunt SA, Abraham WT, Chin MH, et al. 2009 Focused update incorporated into the ACC/AHA 2005 Guidelines for the Diagnosis and Management of Heart Failure in Adults: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines: developed in collaboration with the International Society for Heart and Lung Transplantation. Circulation 2009;119(14):e391-479.
20. Lindenfeld J, Albert NM, Boehmer JP, et al. Executive summary: HFSA 2010 comprehensive heart failure practice guideline. J Card Fail 2010;16:475-539.
21. Malcom J, Arnold O, Howlett JG, et al. Canadian Cardiovascular Society Consensus Conference Guidelines on heart failure-2008 update: best practice for the transition of care of heart failure, and the recognition, investigation and treatment of cardiomyopathies. Can J Cardiol 2008;24(1):21-40.
22. Riegel B, Moser DK, Anker SD, et al. State of science: promoting self care in persons with heart failure: a scientific statement from the American Heart Association. Circulation 2009;120:1141-63.
23. Arnold JM, Liu P, Demers C, et al. Canadian Cardiovascular Society consensus conference recommendations on heart failure 2006: diagnosis and management. Can J Cardiol 2006;22(1):23-45.
24. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform 2009;42(2):377-81.
25. National Cholesterol Education Program. National Heart LaBINIoH. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Final report. Circulation 2002;106(25):3143-421.
26. Holbrook JT, Patterson KY, Bodner JE, et al. Sodium and potassium intake and balance in adults consuming self-selected diets. Am J Clin Nutr 1984;40(4):786-93.
27. Caggiula AW, Wing RR, Nowalk MP, et al. The measurement of sodium and potassium intake. Am J Clin Nutr 1985;42(3):391-8.
28. Arcand J, Floras JS, Azevedo E, et al. Evaluation of 2 methods for sodium intake assessment in cardiac patients with and without heart failure: the confounding effect of loop diuretics. Am J Clin Nutr 2011;93(3):535-41.
29. Arcand J, Floras V, Ahmed M, et al. Nutritional inadequacies in patients with stable heart failure. J Am Diet Assoc 2009;109(11):1909-13.
30. Arcand J, Brazel S, Joliffe C, et al. Education by a dietitian in patients with heart failure results in improved adherence with a sodium-restricted diet: a randomized trial. Am Heart J 2005;150(4):716.e1-5.
31. Welsh D, Lennie TA, Marcinek R, et al. Low-sodium diet self-management intervention in heart failure: pilot study results. Eur J Cardiovasc Nurs 2013;12(1):87-95.
32. Green CP, Porter CB, Bresnahan DR, et al. Development and evaluation of the Kansas City Cardiomyopathy Questionnaire: a new health status measure for heart failure. J Am Coll Cardiol 2000;35(5):1245-55.
33. Flynn KE, Lin L, Ellis SJ, et al. Outcomes, health policy, and managed care: relationships between patient-reported outcome measures and clinical measures in outpatients with heart failure. Am Heart J 2009;158(4 Suppl):S64-71.
34. DiNicolantonio J, Di Pasquale P, Taylor RS, et al. Retraction notice. Low sodium versus normal sodium diets in systolic heart failure: systematic review and meta-analysis. Heart 2013;99:820.
35. DiNicolantonio J, Di Pasquale P, Taylor RS, et al. Low sodium versus normal sodium diets in systolic heart failure: systematic review and meta-analysis. Heart 2012. http://dx.doi.org/10.1136/heartjnl-2012-302337.
36. Anand IS, Fisher LD, Chiang YT, et al. Changes in brain natriuretic peptide and norepinephrine over time and mortality and morbidity in the Valsartan Heart Failure Trial (Val-HeFT). Circulation 2003;107(9):1278-83.
37. Januzzi JL, van Kimmenade R, Lainchbury J, et al. NT-proBNP testing for diagnosis and short-term prognosis in acute destabilized heart failure: an international pooled analysis of 1256 patients: the International Collaborative of NT-proBNP Study. Eur Heart J 2006;27(3):330-7.
38. Whelton PK, Appel LJ, Sacco RL, et al. Sodium, blood pressure, and cardiovascular disease. Further evidence supporting the American Heart Association Sodium Reduction Recommendations. Circulation 2012;126:2880-9.

Appendix. Supplementary data

Randomization, data collection, and treatment allocation

Randomization was performed by using a block randomization with variable block sizes via an automated Web-based system coordinated by the EPICORE Centre at the University of Alberta. Only the dietitian, who delivered the dietary intervention, and the patient were aware of the study group allocation. Patients were asked to discuss any issue related to the diet with the research dietitian and not inform the rest of the research or clinical team about the level of sodium restriction to which they were assigned.

Dietary intervention

Dietary materials and daily menus were predeveloped by a dietitian. In the moderate-sodium diet (100 mmol or 2300 mg daily), patients were encouraged to avoid sodium-rich foods (processed, packaged, preprepared, cured, and fast foods) and to limit condiments such as mustard, ketchup, soy sauce, teriyaki sauce, and salad dressings. Patients in this group were allowed to use only 1/4 of teaspoon of salt (575 mg sodium) a day for preparing their meals (to cook meat, potato, pasta, bean, or to prepare homemade salad dressings). In the low-sodium diet (65 mmol or 1500 mg daily) group, patients were told to avoid sodium-rich foods (processed, packaged, preprepared, cured, and fast foods) and condiments such as mustard, ketchup, soy sauce, teriyaki sauce, and salad dressings. They were also asked to use low- or free-sodium cereals. Patients in this group were not allowed to use salt for cooking or at the table; they were encouraged to flavor foods with lemon juice, vinegar, herbs, spices, garlic, onions, and no added salt seasonings instead of salt.

Dietary intake evaluation

Patients were instructed to record all food and beverages consumed using standard *household measures* (eg, cups and tablespoons) or commercial measures (eg, weight of commercially packaged foods as given on the label, number of servings, or pieces consumed). Patients were asked to provide the *Nutrition Facts Label* of the packaged foods, when possible. Patients also recorded if any condiments or salt was added at the table or during cooking. If the amount of salt could not be measured in household measures, patients were asked to record the number of pinches or shakes added to the food so that sodium could be estimated. All food records were reviewed by the dietitian during interview with the patient to clarify food item descriptions and portion sizes and to identify any missing food items. Food records were analyzed by trained personnel, with a nutrient software program (ESHA Food Processor SQL v.10.11; ESHA Research, Salem, OR). Additional food items were added to the ESHA database when none of the food items contained in the current database reflected the actual food consumed by the patient (eg, no salt added homemade food, restaurant meals, etc). Food records entered for analysis were checked twice for accuracy by independent coders. A mean dietary intake from the 3 days was estimated for energy, sodium, and total fluids. Beverages (water, coffee, tea, juices, soft drinks, etc), soups, juicy fruit, and jello were considered for total fluid estimation.