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Original article

Use of dietary sodium intervention effect on neurohormonal and fluid overload in heart failure patients: Review of select research based literature

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ABSTRACT

Aim: This literature review analyzed ten articles investigating the effects of low dietary sodium intake on neurohormonal and fluid overload on heart failure (HF).
Background: Recommendations for low dietary sodium to HF patients has been debated in the past one to two decades.
Methods: This report presents a literature review of interventional studies from 2006 to 2015 investigating adult HF patients.
Results: The results of the neurohormonal outcome variables seem to be the primary consideration for recommending a low sodium diet to patients with HF. Most of articles in this review reported that 2.6–3 g/day of dietary sodium is effective for decreased BNP, renin, and aldosterone (neurohormonal) plasma levels in patients with HF.
Conclusions: We have to provide the reason, effect, and amount of dietary sodium when providing dietary sodium recommendations to patients.

1. Introduction

On the basis of data from National Health and Nutrition Examination Survey 2009 to 2012, there are approximately 5.7 million patients with heart failure (HF) in United States (American Heart Association, 2015). Fluid overload is the characterizing feature of HF. Fluid management is important in the treatment for HF (Ronco et al., 2012). Excessive sodium intake has been associated with fluid retention. HF patients are unable to excrete a normal sodium load and subsequently develop hemodynamic abnormalities and cardiac maladaptation to the excess of sodium (Volpe et al., 1993). Therefore, the guidelines for the treatment of the HF from the American College of Cardiology Foundation/American Heart Association (ACCF/AHA) recommend that low dietary sodium is considered an essential part of the management of symptoms related to fluid overload (Yancy et al., 2013).

However, several experts have reported different opinions. For example, Alvelos et al. (2004) suggested that 2.3 g/day of dietary sodium may be destroying neurohormones of counter–regulatory mechanism and are harmful to body fluid state for New York Heart Association functional class (NYHA class)I-II HF patients. NYHA functional class classification ranges from I to IV and patients in a lower stage have a lower HF severity (Yancy et al., 2013). Velloso et al. (1991) studied a series of NYHA class III-IV HF inpatients. These researchers showed that there was no significant difference between dietary sodium of 4.0 g/day and 0.8 g/day with regard to the time needed for compensation of HF. Therefore, the study suggested that a dietary sodium 4.0 g/day not adversely influence in-hospital compensation of severe congestive heart failure. This literature analyzes and summarizes the results of research articles pertaining to the effect on neurohormonal factors and fluid overload (body weight) in HF patients. The results of these research articles support the relationship between sodium intake and HF.

2. Methods

A review of research articles was undertaken by searching computerized databases (CINAHL, MEDLIN, ProQuest Nursing Allied Health, and PubMed) using the search terms: heart failure, sodium, salt and dietary.

We included studies that met the following criteria: 1) articles from 2006 to 2015, 2) studies of HF patients who were 18 years or older, 3) intervention study, 4) intervention related to dietary sodium, and 5) neurohormonal or fluid volume as outcome variables. Neurohormonal variable refers to B-type Natriuretic Peptide (BNP), renin, angiotensin II, and aldosterone plasma levels; fluid volume variable refer to body

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weight.

Exclusion criteria were as follows: 1) literature reviews, 2) articles that studied the effects of nursing styles, 3) articles that examined the effects of nutritional knowledge to improve dietary sodium adherence, 4) articles that investigated whether changes in dietary sodium intake and posture contribute to neurohormonal plasma level variations. There were two dimensions in the data extraction: the characteristics of the included articles and the outcome variables.

3. Results

3.1. Characteristics of the included articles

A total of ten research articles were identified related to dietary sodium intervention in the past decade. The study design of most of the articles was blind and randomized. The study period ranged from 7 days to 57 months. The total number of patients in each research article ranged from 12 to 1927 patients. The total drop-out number of patients in each research article ranged from 0 to 1050 patients (3 articles did not report their drop-out rate). All included articles were performed on patients with a Left Ventricular Ejection Fraction (LVEF) of < 45%. The age range of patients was from 52 years to 76 years. Most of the patients were males. The level of HF severity ranged from NYHA class I to IV; most of the patients were NYHA class III.

The tested interventions exhibited a number of differences in the articles. One out of ten articles tested the intervention of sodium intake. Five out of ten articles reported that the intervention consisted of sodium and fluid intake. Three out of ten articles reported that the intervention consisted of sodium, fluid intake and furosemide (diuretic). One out of ten articles reported that the intervention consisted of sodium, fluid intake, furosemide, and hypertonic saline solution.

In this article, the low sodium group was defined as the group that received a relatively lower amount of dietary sodium between the two groups (control and intervention groups) in the included study. The high sodium group was defined as the group that received a relatively higher amount of dietary sodium between the two groups (control and intervention groups) in the included study. All included articles reported that the low sodium group was established as the amount of dietary sodium, which ranged from 0.8 g to 3.0 g/day. Eight out of ten studies reported that the high sodium group was established as the amount of sodium in the diet ranging from 1.5 g to 5.8 g/day. The remaining one article did not report the amount of sodium in the diet. Most of articles included in this review obtained an accurate assessment of patients sodium intake by a telephone interview (or recommendations) and provided standard diet protocols (sample menus). These results are summarized in Table 1.

3.2. Outcome variables

These results are summarized in Table 2.

3.2.1. Neurohormonal variables

3.2.1.1. B-type natriuretic peptide. Seven articles included BNP plasma levels as an outcome variable. Aliti et al. (2013) showed no significant difference in the BNP plasma levels between-groups (770 ng/dL compared with 954 ng/dL, p = 0.51); the high sodium intake group (3–5 g/day) had more participants with a BNP plasma level < 700 ng/dL at 30-day follow-up. The authors concluded that in patients with HF NYHA III-VI, the intake of dietary sodium of 0.8 g/day were unnecessary.

Colin-Ramirez et al. (2015) showed that BNP plasma levels significantly decreased from baseline to 6 months of follow-up in the low sodium group (≤1.5 g sodium/day) (199 pg/dL in the high sodium intake group vs. 118 pg/dL in the low sodium intake group; p = 0.01); no significant change were found in the BNP plasma levels of patients in the high sodium group (> 1.5 g sodium/day) compared to the low sodium group (176 pg/dL v.s. 108 pg/dL, respectively, p = 0.72). There were no significant differences between-groups for the change of BNP plasma levels over the 6 months (high sodium group was 188 pg/dL; low sodium group was 71 pg/dL, p = 0.08). Therefore, these researchers suggested that dietary sodium equal or < 1.5 g/day is applicable for patients with HF NYHA II-III.

Nakasato, Strunk, Guimaraes, Rezende, and Bocchi (2010) showed that there was no significant differences in BNP plasma levels (p > 0.05) from a dietary sodium intake of 2.6 g/day (190.7 ± 21.1 ng/dL) compared to 0.8 g/day (161.8 ± 20.6 ng/dL). There were no significant differences in BNP plasma levels with a shift of high dietary sodium to low dietary sodium. Nakasato et al. (2010) showed that there was a significant increase in neurohormonal plasma levels (e.g., norpinephrine and aldosterone). Therefore, these researchers suggested that dietary sodium intake of 0.8 g/day not be beneficial to patients with HF NYHA I-III.

There were four articles included in this review pertaining to dietary sodium intake of patients with HF NYHA II-III. The results showed that BNP plasma levels were low in the high sodium group (2.8 g/day) compared with the low sodium group (1.8 g/day) at the time of hospital discharge (355 ± 105 pg/ml compared with 385 ± 115 pg/ml, respectively, p < 0.001, Paterna et al., 2011); at 3 months after discharge (425 ± 125 pg/ml compared with 685 ± 255 pg/ml, respectively, p < 0.001, Paterna, Gaspare, Fasullo, Sarullo, & Di Pasquale, 2008); at 6 months after discharge (data not shown, Paterna et al., 2009) (data not shown, p < 0.0001, Paterna et al., 2008), (345 ± 155 compared with 545 ± 127 pg/ml, respectively, p < 0.0001, Parrinello et al., 2009); at 12 months after discharge (225 ± 130 compared with 681 ± 134 pg/ml, respectively, p < 0.0001, Parrinello et al., 2009). In the other words, a high sodium intake was associated with low BNP plasma levels. Therefore, these researchers suggested that dietary sodium of 2.8 g/day be applicable to patients with HF NYHA II-III.

3.2.1.2. Renin. Four articles examined renin plasma levels as outcome variables. Nakasato et al. (2010) showed that there was no significant difference in plasma renin activity (p > 0.05) from dietary sodium intake of 2.6 g/day (16.26 ± 2.7 ng/dL) to 0.8 g/day (20.64 ± 6.2 ng/dL). However, the other results, in same study, showed that there were significant increases in the neurohormonal plasma level with dietary sodium of 0.8 g/day. Therefore, these researchers concluded that a dietary sodium intake 0.8 g/day may not be beneficial to patients with HF NYHA I-III.

Three articles showed that plasma renin activity was low in the high sodium group (2.8 g/day) compared with the low sodium group (1.8 g/day) 6 months after discharge (3.5 ± 2.7 compared with 4.5 ± 3.1 $ng{\cdot}ml^{-1}{\cdot}h^{-1}$, respectively, p = 0.039, Parrinello et al., 2009); (data not shown; Paterna et al., 2009) (3.65 ± 3.28 compared with 5.74 ± 4.12 $ng{\cdot}ml^{-1}{\cdot}h^{-1}$, respectively, p < 0.0001, Paterna et al., 2008); 12 months (3.4 ± 2.3compared with 5.3 ± 2.9 $ng{\cdot}ml^{-1}{\cdot}h^{-1}$, respectively, p = 0.0001, Parrinello et al., 2009). In summary, high sodium intake was reported to be associated with low plasma renin activity.

3.2.1.3. Angiotensin II. Only one included article examined angiotensin II plasma levels as an outcome variable. Damgaard et al. (2006) invited patients with HF to join their study. All patients (n = 12) were under pharmacological treatment, such as angiotensin converting enzyme inhibitors (n = 11), beta adrenoreceptor blockers (n = 7), diuretics (n = 10), and spironolactone (n = 4). The study showed that angiotensin II plasma level was low at seat rest during high dietary sodium (5.8 g/day) compared with the low dietary sodium (1.6 g/day) (seat rest: 9.6 compared with 21 pg/ml, p > 0.05; supine rest: 14.3 pg/ml, p > 0.05). However, these researchers concluded that high dietary sodium intake suppresses the release of neurohormonal activation and was tolerated without any water retention under pharmacological