

## Original Paper

# Investigating the Relationship between Dietary Sodium Intake and Severity Levels of Fluid Overload Symptoms in Patients with Heart Failure

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### **Abstract**

**Aim:** This study aimed to investigate dietary sodium intake levels and to explore the relationship between those levels and the severity of fluid overload symptoms.

**Background:** The management of dietary sodium is an important nursing intervention in the care of patients with heart failure stemming from fluid overload. Recommendations for the intake of dietary sodium among heart failure patients were discussed. If a heart failure patient's dietary sodium intake habits are understood, then the relationship between this intake and fluid overload can be elucidated. This knowledge would be beneficial for nursing intervention in cases of heart failure.

**Methods:** A total of 98 patients selected from cardiology wards who had a diagnosis of heart failure were enrolled in this study. Their dietary sodium intake level was estimated from a 24-hour urinary sodium excretion analysis. The severity of fluid overload symptoms was assessed using the fluid volume overload symptoms scale.

**Results:** This study showed that the mean dietary sodium intake for patients with heart failure was 2.49 g/day and that this intake had no correlation with the severity levels of fluid overload symptoms.

**Conclusions:** Using the patients' own perceptions of the severity of fluid overload symptoms as a reference, adopting more relaxed sodium dietary intake restrictions may lead patients to have better food consumption habits.

### **Keywords**

dietary sodium, fluid volume overload, heart failure, urine collection

## 1. Introduction

A characteristic feature of patients with Heart Failure (HF) is the presence of a fluid overload. Traditionally, HF patients are advised to follow a low dietary sodium intake food plan in order to improve symptoms of fluid overload, even though, low dietary sodium diets do not taste good to most people. However, there are different dietary recommendations for low-sodium diets based on different clinical practice guidelines. For example, the American College of Cardiology Foundation/American Heart Association recommend that stages A and B HF patients have a dietary sodium intake of 1.5 g/day, while patients with stages C and D have an intake of less than 3.0 g/day (Yancy et al., 2013). The Heart Failure Society of America recommends that HF patients with mild symptoms have a dietary sodium intake of 2.0 to 3.0 g/day, while HF patients with moderate to severe symptoms should have a dietary sodium intake of less than 2.0 g/day (Lindenfeld et al., 2010). The European Society of Cardiology, which does not have low-sodium dietary recommendations for HF patients, has a neutral attitude (Ponikowski et al., 2016). So far, current data indicate inconsistent suggestions for dietary sodium intake in HF patients.

Because low dietary sodium intake is an important nursing intervention in the care of HF patients with fluid overload symptoms, it would be beneficial if we understood the following: (1) what is the daily dietary sodium intake in patient with HF, and (2) what is the relationship between the dietary sodium intake in those patients and their fluid overload symptoms? Therefore, the purpose of this study was (1) to investigate dietary sodium intake, and (2) to explore the relationship between this intake and the severity of fluid overload symptoms.

## 2. Method

### 2.1 Ethical Considerations

This study was approved by the institutional review board of the hospital (NO103-6198B). Each patient provided written consent prior to participating in the study.

### 2.2 Design and Sample

This was a non-experimental research study performed with inpatients. The following inclusion criteria were established: the patients were admitted with HF based on medical records, the patients were alert and oriented, the patients had the ability to speak Taiwanese or Chinese, and the patients' serum creatinine levels were  $\leq 2.06$  mg/dL for females or  $\leq 2.54$  mg/dL for males. Exclusion criteria were as follows: dementia, renal disease, hepatic disease, respiratory disease, peripheral vascular disease, diarrhea and fever based on medical record examination, being under a ventilator, undergoing hemodialysis, undergoing fasting treatment, history of a blood transfusion, history of intravenous saline infusions, and being available for urine collection. A convenience group of 106 inpatients, recruited from the cardiology wards of the hospital, was invited to join this study.

### 2.3 Procedures for Data Collection

The patients who met the eligibility criteria were asked for a 24-hour urine collection sample. For the urine collection, the data collector (first author) explained to the patients the specifics of a 24-hour urine collection (e.g., urine collection start and end times) and visited the patients three to four times during the time of urine collection. The data collector asked the patients how many times they encountered a loss of a urine sample during the 24-hour period. The sample was excluded if the patients reported a sample loss of more than 2 times.

After finishing the 24-hour urine collection, the data collector asked the patients to complete the Fluid volume Overload Symptoms Scale (FOSS) survey. If patients were illiterate or had any visual difficulty, the data collector read the contents of the FOSS survey to the patients who then provided their answers. The New York Heart Association (NYHA) functional classification system was used to measure the severity of HF. The measurement method relied on the data collector asking the patients about the status of their symptoms while performing their normal daily activities. Subsequently, the data collector finished the NYHA functional classification system according to the patients' answers.

All of the patients' demographic (age, gender, marital status, and education) and clinical data (current medications, serum creatinine levels, and left ventricular ejection fraction rates) were collected by a review of their medical records.

### 2.4 Instruments

Biochemical analyses (Hitachi 7600 series automation system clinical analyzer), FOSS, and the NYHA functional classification survey were major instruments for data collection.

Urinary sodium concentration was checked by biochemical analysis. A 24-hour urinary sodium excretion level was calculated as follows: the total amount of urine excreted in 24 hours multiplied by the urinary sodium concentration, multiplied by 0.001 (to turn a milliequivalent value to an equivalent value), and then multiplied by 23 (one equivalent of sodium ions is 23 grams). A 24-hour dietary sodium intake level was calculated by multiplying the total amount of the 24-hour urinary sodium excretion (grams) by 100/82. According to Kimira, Kudo, Takachi, Haba, and Watanabe (2004), urinary sodium excretion levels are positively correlated with dietary sodium intake, and the 24-hour urinary sodium excretion level is approximately 82% of sodium intake levels.

In summary, the formula for calculating dietary sodium intake levels was as follows:

$$\text{24-hour dietary sodium intake (grams)} = \text{amount of 24-hour urine (L)} \times \text{urinary sodium concentration (mEq/L)} \times 0.001 \text{ (eq/mEq)} \times 23 \text{ (g/eq)} \times 100/82$$

The accuracy of the biochemical analysis of the urinary sodium concentration assay was developed in a process that included four steps. The first step was the collection of a 24-hour urine sample from HF patient ( $n = 5$ ) in a collection bucket. The second step involved using a glass rod to stir the urine to achieve a uniform concentration of solutes in the urine collection bucket. The third step involved collecting urine samples from the buckets by using a dropper and placing the samples in two tubes (3 ml each). The fourth step included checking for accuracy by an independent test of the two tubes

containing the urine sample. The accuracy of the biochemical analysis in the urinary sodium concentration assay was thus ensured in this study (Spearman rho.1,  $p < .01$ ).

The FOSS survey was used to measure the severity of fluid overload symptoms. The FOSS survey is a self-report that takes approximately 2 minutes to complete and has 7 items with scores ranging from 0 to 28 points. The response options were evaluated with a 5-point scale: asymptomatic patients were assigned a score of 0, while patients perceiving greater severities of fluid overload symptoms were assigned higher scores. The construct validity of the FOSS survey was supported by Exploratory Factor Analysis. The total explained variance was 69.97%. Its Cronbach's alpha value was 0.85, after measurements taken from inpatients with HF accompanied by fluid volume overload symptoms in a study by Lee, Jeng, and Huang (2015). Cronbach's alpha was 0.79.

The NYHA functional classification system is used in clinical practice to assess the severity of HF and is commonly applied in research to assess the capacity for daily activities as well as the symptomatic status of disease in HF patients (e.g., Fu et al., 2016; Ogunmola, Akintomide, & Olamoyegun, 2013). There are four stages in the NYHA functional classification system. Patients with a lower stage rating tend to have lower HF symptom severity, while patients with a higher stage rating tend to have greater HF symptom severity. In this study, the reliability of the NYHA functional classification survey was tested in 10 patients with HF, and it was established that the questionnaire was satisfactory in its reliability (Spearman rho.88,  $p < .001$ ).

### 3. Result

After collection, the data were analyzed for statistical significance using SPSS 17.0 software. All tests required an alpha value equal to or less than .05 for statistical significance.

#### 3.1 Description of the Population

One hundred and sixteen patients were recruited for this study. Eleven out of 116 were rejected from the study. Five out of 116 patients were discharged during the study. Two out of 116 patients were excluded because of outlier values. Finally, a total of 98 patients were entered into the study. The patients had a mean left ventricular ejection fraction rate of  $44 \pm 18\%$ . The patients had a mean age of  $73 \pm 14$  years; 64% were males; 65% had an education level of junior high school or less; 87% were married; 37% were classified as NYHA functional class III. The serum creatinine levels were  $1.40 \pm 0.47$  mg/dL and  $1.21 \pm 0.48$  mg/dL in males and females, respectively. Regarding drug interventions, 73% of the patients took furosemide; 44% took  $\beta$ -adrenergic antagonists; 40% took coronary artery dilatation agents; 31% took aldosterone receptor antagonists; 32% took angiotensin II receptor blockers; 20% took digoxin; 10% took calcium channel blockers; 8% took angiotensin-converting enzyme inhibitors; and 4% took positive inotropic therapy (Table 1).

**Table 1. Demographic and Clinical Characteristics of the Patients (n = 98)**

Sample characteristics*	
Age (years)	73 ± 14
Gender	
Male	64
Female	36
Education:	65
Junior high school or less	35
More than Junior high school	
Marital status:	87
Married	13
Other (e.g., widowed, divorced, or never married)	
NYHA functional classification	
I	20
II	35
III	37
IV	8
Serum creatinine (mg/dL)	
Males	1.40 ± 0.47
Females	1.21 ± 0.48
Medications	
Furosemide	73
β-adrenergic antagonists	44
Coronary artery dilatation agent	40
Aldosterone receptor antagonist	31
Angiotensin II receptor blocker	32
Digoxin	20
Calcium channel blocker	10
Angiotensin-converting enzyme inhibitors	8
Positive inotropic	4

\* Continuous variables expressed as the mean ± SD and categorical variables expressed as %.

### 3.2 Dietary Sodium in Patients with Heart Failure

The result of the study shows that patient dietary sodium intake mean was  $2.49 \pm 1.53$  g/day (n = 98). Patients with an NYHA functional classification of I, II, III, and IV had dietary sodium intake means of  $2.53 \pm 1.71$  g/day (n = 20),  $2.76 \pm 1.73$  g/day (n = 34),  $2.37 \pm 1.29$  g/day (n = 36), and  $1.79 \pm 1.05$

g/day (n = 8), respectively. However, the results of Kruskal-Wallis test showed that there was no significant difference among them in dietary sodium intake ( $\chi^2 = 2.44$ ,  $p = .49$ ).

### 3.3 Dietary Sodium Intake and Severity of Fluid Overload Symptoms

There was no significant correlation between the 24-hours urinary sodium excretion levels and the FOSS survey scores ( $r = .05$ ,  $p = .64$ ), indicating that severity of fluid overload symptoms was not affected by dietary sodium intake.

## 4. Discussion and Conclusion

Some studies have suggested that since race and living locations and conditions differ from culture to culture, one can expect daily dietary sodium intake to also be different (Kollipara et al., 2006; World Health Organization, 2006). However, the results of our study show that patient dietary sodium intake trends are similar to Lemon (2010), who reported that patient dietary sodium intake was 2.7 g/day on average. Additionally, the results of this study show that patients with an NYHA functional classification of II had a dietary sodium intake mean of  $2.76 \pm 1.73$  g/day, while patients with an NYHA functional classification of III had a dietary sodium intake mean of  $2.37 \pm 1.29$  g/day. The results of this study also show that patients' dietary sodium intake are also similar to some studies that reported the following: patients with an NYHA functional classification of II and III, and who are mostly African American patients with HF, had a dietary sodium intake mean of  $2.67 \pm 1.43$  g/day (Frediani et al., 2013), while a different study reported that patients with an NYHA functional classification of II and III, and who were African patients with HF, had a dietary sodium intake mean of 2.4 g/day (Pretorius et al., 2012).

Dietary sodium intake can be estimated from food intake (e.g., multiple day food recalls, food records, and food intake frequency questionnaires) or from urine samples (e.g., spot urine collection and 24-urine collection) (Colin, Arcand, & Ezekowitz, 2015). The Leiba, Vald, Peleg, Shamiss, and Grossma (2005) study suggested that an estimated dietary sodium intake from a 24-hour food record was positively correlated with a 24-hour urine collection ( $r = .43$ ,  $p < .001$ ). Charlton, Yeatman, Houweling, and Guenon (2010) reported that the dietary sodium intake estimated from a 24-hour food record was higher than that from a 24-hour urine collection. Espeland et al. (2001) reported that the estimated dietary sodium intake from both urine and food records had a 10% gap.

According to our experience with this pilot study, if HF patients were illiterate or had visual difficulties, they often failed to properly record their food record. In addition, the majority of subjects in this study were elderly patients, and they display symptoms related to HF (e.g., dyspnea and fatigue). The researchers were concerned that patients with HF often failed to properly recall their food intake. Furthermore, food frequency questionnaires become a burden to the patients. Therefore, we decided that the dietary sodium intake should be estimated from the urine collection sample alone.

Milne, Gear, Laidley, Ritchie, and Schultz (1980) reported that a 24-hour urinary sodium excretion calculation was significantly associated with a spot urine sodium excretion calculation at 9 a.m. ( $r$

= .46). According to our experience in this pilot study, patients with HF often fail to record the urine amount during their spot urine collections, contrary to their doctor's order for fluid management. Patients with HF were mistaken in their belief that they did not need to record the amount of urine during their spot urine sample collections. According to the World Health Organization (2006), 24-hour urinary sodium excretion calculations should be considered as the gold standard method for obtaining data on dietary sodium intake. The elderly, who have small changes in their daily diets, can have their dietary sodium intake reliably estimated from a 24-hour urinary sodium excretion analysis; however, a high burden exists for patients with the 24-hours urine collections (World Health Organization, 2006). Thus, using the same assumptions, we estimated that there were small variances in the quality and quantity of daily diets in HF patients. The study estimated dietary sodium intake levels from a 24-hour urinary sodium excretion analysis. To eliminate any interference factors, the urine collection times excluded specific holidays, such as The Dragon Boat Festival and The Mid-Autumn Festival. During the 24-hour urine collection period, a data collector reminded patients (3 times to 4 times per day) to place their urine in the urine bucket for complete collection, and the data collector asked nurses to help patients record their urine amounts, as per their doctor's orders.

The current study results were not completely consistent in the relationship between low-dietary sodium levels and the severity of fluid overload symptoms in HF patients. Velloso et al. (1991) adopted a neutral attitude on the effects of low-sodium dietary levels in HF patients with an NYHA functional classification of III or IV. Their study reported that there was no significant difference in the percentage of weight loss (12.2% vs 10.0%) between 0.8 gm of dietary sodium per day and 4.0 gm of dietary sodium per day in HF patients with an NYHA functional classification of II and IV.

Some studies have reported that low-sodium dietary consumptions offer advantages to patients with HF. Some studies reported that low-sodium dietary levels (2 to 2.4 g/day) were good for patients with HF (Philipson, Ekman, Forslund, Swedberg, & Schaufelberger, 2013; Philipson, Ekman, Swedberg, & Schaufelberger, 2010), which can lead to a decrease in extracellular fluid volume (Colin et al., 2004). Son, Lee, and Song (2011) showed that for patients with an NYHA functional classification of III and IV, a low-sodium dietary intake of below 3.0 g per day improved the burden of symptoms more than a consumption greater than 3.0 g.

Lymperopoulos, Rengo, and Koch (2013) and Sica (2006) reported that two neurohormonal systems (the antinatriuretic and antidiuretic systems versus the sympathetic nervous and the renin-angiotensin-aldosterone systems) exert counter-regulatory mechanisms to maintain a constant body fluid volume. If the relative equilibrium between the two systems is disturbed, this will lead to a fluid volume overload and may result in heart failure.

Some studies have reported low-sodium dietary disadvantages in patients with HF. These studies suggested that the pathophysiology of fluid retention in HF was related to neurohumoral factors. For example, Alvelos et al. (2004) suggested that dietary sodium intake (2.3 g/day) may be related to the activation of antinatriuretic and antidiuretic systems in mild to moderate HF patient. Thus, low dietary

sodium may be destroying counter-regulatory mechanism harmful to body fluid states. Nakasato, Strunk, Guimaraes, Rezende, and Bocchi (2010) suggested that dietary sodium intake (2.0 g/day) may be related to the increase in plasma levels of norepinephrine and aldosterone and a decrease in natriuretic peptide for HF patients with an NYHA functional classification of I, II, and III. Such an activation may worsen the two homeostatic systems, leading to fluid overload.

In addition, Paterna et al. (2011) suggested that 2.8 g of dietary sodium intake per day was better than 1.8 g in preventing fluid overload in HF patients with an NYHA functional classification of II or III. They reasoned that 1.8 g per day may disrupt counter-regulatory mechanisms. These results of neurohormonal outcome variables seem to be a primary priority to consider for dietary sodium intake recommendation for HF patients.

Licata et al. (2003) reported that HF patients with an NYHA functional classification of IV who receive 2.8 g/day of sodium and a hypertonic saline solution combined with an intravenous 30-minute infusion of 1-2 g/day of furosemide (diuretic), show more improvements in body weight (as a fluid indicator) than patients receiving 1.8 g/day of sodium and an intravenous bolus of 1-2 g/day furosemide. They suggested that the mechanisms of high doses of sodium may comprise the mobilization of extravascular fluid into the intravascular space through an osmotic gradient, and an increased urine amount through an increase in renal blood flow, and postulated that this may promote body weight loss. Fluid overload symptoms in HF patients are a complex issue. According to the above mentioned review, we know that causes of fluid overload symptoms in HF patients are not only related to dietary sodium but also to other factors, such as neurohumoral, osmotic pressure gradients between the extravascular space and intravascular space.

In conclusion, this study showed that HF patients with an NYHA functional classification of I, II, III, or IV had a dietary sodium intake levels of 2.53, 2.76, 2.37, and 1.79 g/day, respectively, with a mean of 2.49 g/day. This study also showed that the amount of dietary sodium had no correlation with the levels of severity of fluid overload symptoms. Based on this result, this study suggests allowing patients who are under medical treatment to perceive of their own fluid overload symptoms severity as a reference in order to adopt a more liberal sodium dietary intake and plan a more balanced food diet.

To our knowledge, in Taiwan, there were no investigations of data related to the daily dietary sodium intakes of HF patients, and no studies using a 24-hour urine collection approach in HF patients to estimated daily dietary sodium intakes. Additionally, no study to date has explored the relationship between the amounts of dietary sodium intake and self-perception of the severity of fluid overload symptoms. The results of this study are a useful contribution to the knowledge gap that exists in HF patients and dietary sodium intake levels. This study's report provides a useful clinical care reference.

However, this study has some limitations. First, the study's subjects were inpatients. Therefore, the results of this study are not easily relatable to a general outpatient and clinically stable patient population. Second, there is a potential confounding factor related to medication effects. Thus, we would like to remind the readers that the appropriate application of these results should be patients



undergoing a medical treatment with self-perceived severities of fluid overload symptoms. Third, this study's dietary sodium intake calculations may be an underrepresentation, because dietary sodium intake levels were estimated from a 24-hour urinary sodium excretion analysis alone. Fourth, patients with an NYHA functional classification of IV are usually the more severe and symptomatic HF patients. They usually present as weak, with shortness of breath and dyspnea. Their participation in the study was not easy. However, only eight percent of participants in this study's sample had a functional classification of IV.

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