

Effect of Thermal Therapy Using Hot Water Bottles on Brain Natriuretic Peptide in Chronic Hemodialysis Patients

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Received: June 11, 2012 / Published online: August 1, 2012

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ABSTRACT

Introduction: The use of repeated thermal therapy for improving the symptoms of chronic heart failure (CHF) has been recently demonstrated. Usually, thermal therapy requires an infrared dry sauna. However, it is difficult for small clinics to acquire such an expensive and extensive system. The present study assessed the efficacy of its substitution with hot water bottles. Moreover, there are no prior studies demonstrating the efficacy of thermal therapy in hemodialysis patients with CHF.

Methods: Plasma brain natriuretic peptide (BNP) levels were evaluated in 98 hemodialysis patients in a clinic. Nine patients whose BNP levels were >500 pg/mL agreed to be enrolled in

the study and received thermal therapy using hot water bottles.

Results: Plasma BNP levels, a potential marker for CHF, tended to decrease (891 ± 448 to 680 ± 339 pg/mL), but the difference was not significant ($P = 0.0845$). The oral temperature changed from $36.44 \pm 0.45^\circ\text{C}$ to $37.04 \pm 0.48^\circ\text{C}$ ($+0.597^\circ\text{C}$, $P < 0.0001$). No side effects were experienced during the therapy. Moreover, most patients had an improvement in their symptoms and the ability to perform activities of daily living.

Conclusion: Thermal therapy using hot water bottles is very safe and tends to reduce plasma BNP levels in hemodialysis patients with CHF.

Keywords: BNP; Brain natriuretic peptide; Chronic heart failure; Chronic kidney disease; Hemodialysis; Hot water bottle thermal therapy

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INTRODUCTION

Chronic heart failure (CHF) is a major, serious complication for hemodialysis patients [1–3]. Kihara et al. and Miyata et al. [4–6] recently reported that repeated thermal therapy could improve hemodynamics and symptoms in

patients with CHF. The therapy requires an infrared-ray dry sauna because the temperature needs to be maintained evenly at 60°C. Unfortunately, it is difficult for small clinics to acquire such an expensive and extensive system. Kihara et al. and Miyata et al. [4–6] proposed warm water baths as a substitute for saunas, which can warm the body without overloading the heart.

The present study assessed whether thermal therapy for CHF using hot water bottles can be used as a substitute for infrared-ray dry sauna, and whether thermal therapy is useful for hemodialysis patients with CHF as there have been no studies demonstrating the efficacy of thermal therapy in this patient population. Brain natriuretic peptide (BNP) was used to assess left ventricular (LV) function as it is superior to volume overload in heart failure patients with normal kidney function [7]. A high water volume exists in hemodialysis patients because of hypouresis.

MATERIALS AND METHODS

Study Design and Participants

The study procedures were in accordance with the guidelines of the 2000 Declaration of Helsinki for human experimentation. All patients provided informed consent. Nine out of 98 inpatients undergoing hemodialysis treatment in November 2007 at the Hosoe clinic, and whose BNP levels were >500 pg/mL were enrolled in this study. Patients with arterial ventricular stenosis and other outflow obstacle heart disease were excluded as thermal therapy is contraindicated in these conditions [4, 5]. None of the nine patients had any signs, symptoms, or history of cancer or any active inflammatory disease.

Laboratory Measurements

To evaluate BNP levels after hemodialysis, blood samples of the patients were collected in the supine position. Plasma samples were prepared within 30 min after collection using a pre-cooled centrifuge. Extracted plasma samples were frozen immediately and stored at –20°C until analysis. Plasma BNP concentrations were measured by an immunoradiometric assay specific for human BNP using a commercial kit (Shionogi BNP kit; Shionogi Co. Ltd., Osaka, Japan). Repeat blood samples were collected 3 months later at the end of the follow-up period. The oral temperature was measured before and after each therapy session.

Thermotherapy Using Hot Water Bottles

Patients were interviewed and evaluated as to their ability to perform activities of daily living (ADL), and heart failure was classified using the classification of New York Heart Association (NYHA) before and after the study.

Before the study, all patients were treated with beta-blockers, angiotensin II-converting enzyme inhibitors, and angiotensin II-receptor blockers according to the treatment guidelines for the evaluation and management of CHF [8]. Drug treatment was continued throughout the study. After an examination that involved measuring patients' dry weight, and assessing X-ray images and other clinical parameters, such as blood pressure, patients received thermal therapy using hot water bottles. This therapy is derived from the thermal therapy using an infrared-ray dry sauna invented by Kihara et al. and Miyata et al. [4, 5]. Initially, patients received a hot water foot bath (44°C) for 30 min. Subsequently, patients were then asked to lie down on a bed with hot water bottles and were wrapped in a blanket for

another 30 min. This procedure was repeated three times per week after hemodialysis for a total follow-up period of 3 months.

Statistical Analysis

Values are expressed as the mean \pm SD. Student's *t* test was used for all comparisons. *P* values less than 0.05 were considered significant.

RESULTS

Demographic and clinical characteristics of the patients are summarized in Tables 1 and 2, respectively. Before the study, the patients' ability to perform ADL was assessed. If, despite high BNP levels, the patients did not complain of NYHA-defined heart failure-related symptoms, it was speculated that it might have been difficult for hemodialysis patients with many co-morbidities causing pain and joint problems to differentiate the symptoms related to heart failure. Each patient underwent thermal therapy three times per week after hemodialysis for 3 months. The nine patients who were included in the analysis (2 men and 7 women; mean age 74.2 ± 14.6 years old; average duration of hemodialysis 8.3 ± 6.2 years) were able to continue thermotherapy and were observed for 3 months. Plasma BNP levels in the peripheral blood changed from 891 ± 448 pg/mL (range 419–1,627 pg/mL) to 680 ± 339 pg/mL (range 208–1,100 pg/mL) after 3 months ($P = 0.0845$). The changes in plasma BNP levels were not significant, but the levels tended to decrease. The oral temperature changed from $36.44 \pm 0.45^\circ\text{C}$ to $37.04 \pm 0.48^\circ\text{C}$ ($+0.597^\circ\text{C}$, $P < 0.0001$). After 3 months of thermal therapy, the ADL score improved in all patients (Table 2).

Table 1 Demographic characteristics, and present heart disease and other conditions of the study population

Case	Age (years)	Sex	Duration of hemodialysis (years)	Heart disease
1	79	Female	5.0	SN/AR moderate
2	79	Male	6.0	CGN/MR mild
3	53	Female	15.0	DM/LVH
4	83	Female	3.0	DM/OMI
5	73	Female	13.0	PKD/MR and LVH mild
6	80	Female	5.0	DM/MR and AR
7	47	Male	6.0	SN/MR
8	90	Female	2.0	MR/AR and LVH
9	84	Female	20.0	PKD/MR

AF atrial fibrillation, *AR* aortic valve regurgitation, *CGN* chronic glomerular nephropathy, *DM* diabetic nephropathy, *LVH* left ventricular hypertrophy, *MR* mitral valve regurgitation, *OMI* old myocardial infarction, *PKD* polycystic kidney disease, *SN* sclerosis nephropathy

Other clinical parameters, such as blood pressure, dry weight, anemia, and cardiothoracic ratio did not change significantly (data not shown). Results of the echocardiogram tests conducted before and after the study period revealed no significant change in the ejection fraction and other associated parameters (data not shown). No side effects were experienced during the therapy.

DISCUSSION

Results of this study suggest that the ability of hemodialysis patients to perform ADL can be improved with the use of hot water bottle

Table 2 Demographic characteristics of the study population and the experienced symptom change

Case	Age (years)	Sex	Ability to perform ADL ^a	Change in ability to perform ADL	NYHA heart failure classification change
1	79	Female	Pain in the right knee ^b	Disappeared	II → I
2	79	Male	No symptoms	No change	II → I
3	53	Female	Chill, heart palpitation at rest	Disappeared (both symptoms)	II → I
4	83	Female	No symptoms	No change	I → I
5	73	Female	Right hand sclerosis (10/10); abdominal pain after abdominal surgery (10/10); pain in the left knee (10/10); could not perform housework	Improvement in hand movement (6/10), abdominal pain (3/10), knee pain (5/10); could perform some housework ^c	NA
6	80	Female	Back pain	Disappeared ^d	NA
7	47	Male	Could not speak after brain hemorrhage	Became more alert and started speaking ^e	NA
8	90	Female	Pain in both knees	Disappeared ^f	NA
9	84	Female	Pain in the left shoulder, toothache	Disappeared ^g	NA

ADL activities of daily living, NYHA New York Heart Association

^a Symptoms were assessed on a scale from 1 (minimal)–10 (maximum)

^b The duration of knee pain was over a year

^c The patient could not walk for 100 m because of knee pain; after the study the patient could walk 3 km

^d The patient could not walk and used a wheelchair; after the study the patient could walk with a cane

^e The patient could not speak to complain of any symptoms for 5 years, after the study the patient could speak

^f The patient could not walk because of knee pain and used a wheelchair; after the study the patient can walk with a cane

^g The patient was bedridden

thermal therapy, and that such therapy can help to decrease plasma BNP levels. This is the first study to demonstrate that mild thermal therapy is an effective, relatively safe, and easy way to improve the ability to perform ADL, and may also improve LV function in CHF patients.

Thermal therapy, also known as Waon therapy, is defined as “therapy in which the entire body is warmed in an evenly heated chamber for 15 min at a temperature that soothes the mind and body, and after the deep body has increased by approximately 1.0–1.2°C, the soothing warmth continues at rest for an additional 30 min, with fluids supplied at

the end to replace the loss from perspiration” [4].

According to Kihara et al. and Miyata et al. [4–6], although medical progress in the twentieth century has been outstanding, there is still no way of determining the magnitude of a patient’s internal suffering and conflict. Medical staff cannot appreciate the extent of pain, tension, and stress experienced by patients who receive life-saving therapies, especially in the case of CHF patients who are ineligible for operation. Kihara et al. and Miyata et al. [4–6] developed thermal therapy for such patients, and it has been found to improve

hemodynamics and decrease serum BNP levels, arrhythmia, and sympathetic nervous system activity, which occurs with severe cardiac failure. Moreover, this method is an effective treatment for Sjögren's disease and other lifestyle-related diseases, such as hypertension, diabetes mellitus, hyperlipidemia, obesity, and smoking-related diseases [9, 10].

Warming the body has been shown to relieve the sympathetic nervous system [5–7]. Furthermore, it has been shown that it might also improve the immune system [11–13]. Warming the body using hot water bottles warms the patient slowly and does not burden weak patients [11]. In the current medical practice, medical staff often do not have sufficient time to see and talk to patients. Talking and listening to a suffering patient enables them to relax and develop a trusting relationship with the medical team. The time spent with the patient by the medical staff during the thermal treatment might be the most important and effective part of this therapy.

In the present study, most patients reported alleviation of pain and the symptoms impacting the ability to perform ADL during thermal therapy. Warming decreases the activity of the sympathetic nervous system and opens peripheral blood vessels, resulting in relaxation of tendons and muscles [4–6]. Reducing the pain also decreases the activity of the sympathetic nervous system and increases the patient's trust in the medical staff, resulting in more efficient medical care.

There are no previous studies on the appropriate duration of thermal treatment. The effect of sauna therapy after 2–4 weeks has been reported [4–6], and the authors suggest that the therapy was effective for improving the ability to perform ADL in severe heart failure patients when performed once a day for

3–4 days a week. In addition, this method is very easy to implement; hence, the length of each session can vary as required.

Measuring BNP levels is the established parameter for assessing LV function with normal kidney function [7]. However, there are conflicting results concerning assessing renal function, especially in dialysis patients. Many reports recommend using the BNP level as a possible prognostic marker for cardiac disease even in chronic kidney disease (CKD) [14–17]. Park et al. [18] recently reported that the BNP level is a useful marker for assessing the risk of new cardiac events in patients with CKD. There are few reports recommending BNP levels as a prognostic marker for CHF in CKD because BNP levels in hemodialysis patients vary widely. Moreover, the level of BNP in hemodialysis patients can change daily [14, 19]. Although a few reports suggest that the normal BNP level is below 100 pg/dL even in hemodialysis patients [20], other reports most commonly suggest a range of 150–300 pg/dL for patients without heart disease, but this level is not consistently reported and is based on cross-sectional studies [21, 22].

There have been no reports on longitudinal BNP levels in hemodialysis patients. In the present study, BNP levels in hemodialysis patients were evaluated by means of a longitudinal study. In most people without CKD, BNP enhanced LV systolic and diastolic functions. However, the most precise and convenient method for the evaluation of diastolic LV function remains controversial. It is difficult to evaluate diastolic LV function using general ultrasonography [23]. Echocardiography was performed for all patients in the present study, but patients' ability to perform ADL was very poor and correct posture could not be obtained. Some patients also had lung disease with severe calcification.

Among patients on hemodialysis, there are numerous patients with normal ejection fraction, who also have restricted LV function because of chronic volume overload, volume change, hypertension, and/or amyloidosis.

The timing for measuring the BNP level is very important. In the present study, BNP levels were compared in the same patients at different times. Before hemodialysis, weight gain (water volume) values differed each time, but after hemodialysis, dry weight values were fixed for each patient. The BNP level was found to have less of a relationship to water volume, but the levels were measured before and after hemodialysis, and were clearly different. BNP levels were evaluated after hemodialysis. This might be the reason that there was no significant change in BNP levels before and after the study. Interestingly, the BNP level could be used as a marker for LV function in some patients, as shown in the two patients whose BNP levels clearly decreased in the present study (Fig. 1). However, there is no

consensus as to the best time to measure BNP levels in hemodialysis patients, whether it is at the start or end of the week, or pre- or post-hemodialysis. In the present study BNP levels were measured after hemodialysis when weights were fixed and other parameters were stable. It was difficult to find the most convenient and valid parameter to determine heart function in hemodialysis patients. BNP levels decreased in this study, but the decrease was not statistically significant; however, some patients experienced significant decreases in BNP (Fig. 1).

There were several limitations to this study. The number of patients was very limited and the increase of body temperature in the study was 0.597°C, less than 1.0°C suggested by Tei et al. Furthermore, the renal impairment of hemodialysis patients in the present study may lead to accumulation of levels of N-terminal proBNP [7, 15, 24, 25]. Moreover, this study included a small population that was followed up for a very limited duration.

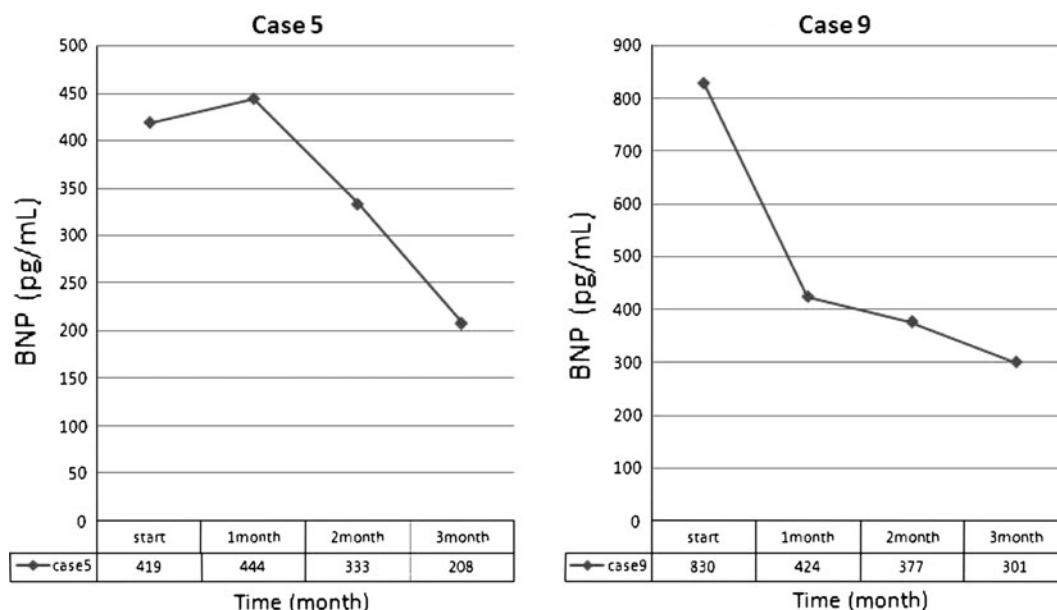


Fig. 1 BNP levels before and after the present study of the two patients whose BNP clearly decreased. *BNP* brain natriuretic peptide

In conclusion, using this convenient and simple method for thermal therapy resulted in an improvement in patients who suffered from pain and experienced difficulty with mobility. The therapy also could be conducted without the side effects associated with other effective therapies. Thermal therapy using hot water bottles is very safe and tends to decrease plasma BNP levels in hemodialysis patients with CHF.

ACKNOWLEDGMENTS

Dr. Uchiyama-Tanaka is the guarantor for this article, and takes responsibility for the integrity of the work as a whole.

Conflict of Interest. The author declares no conflict of interest.

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