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Original Article

Clinical utility of far-infrared therapy for improvement of vascular access blood flow and pain control in hemodialysis patients

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Abstract

Background: Maintenance of a well-functioning vascular access and minimal needling pain are important goals for achieving adequate dialysis and improving the quality of life in hemodialysis (HD) patients. Far-infrared (FIR) therapy may improve endothelial function and increase access blood flow (Qa) and patency in HD patients. The aim of this study was to evaluate effects of FIR therapy on Qa and patency, and needling pain in HD patients.

Methods: This prospective clinical trial enrolled 25 outpatients who maintained HD with arteriovenous fistula. The other 25 patients were matched as control with age, sex, and diabetes. FIR therapy was administered for 40 minutes during HD 3 times/wk and continued for 12 months. The Qa was measured by the ultrasound dilution method, whereas pain was measured by a numeric rating scale at baseline, then once per month.

Results: One patient was transferred to another facility, and 7 patients stopped FIR therapy because of an increased body temperature and discomfort. FIR therapy improved the needling pain score from 4 to 2 after 1 year. FIR therapy increased the Qa by 3 months and maintained this change until 1 year, whereas control patients showed the decrease in Qa. The 1-year unassisted patency with FIR therapy was not significantly different from control.

Conclusion: FIR therapy improved needling pain. Although FIR therapy improved Qa, the unassisted patency was not different compared with the control. A larger and multicenter study is needed to evaluate the effect of FIR therapy.

Introduction

A well-functioning vascular access site and relief of needling pain are important factors for achieving adequate dialysis and improving the quality of life in hemodialysis (HD) patients. Although many surveillance methods have been developed to detect early vascular access dysfunction in patients with arteriovenous fistulas (AVFs), surveillance has not been shown to improve access survival in the grafts [1]. Thus, many researchers have tried to improve vascular access survival with medications and other techniques.

Far-infrared (FIR) radiation comprises electromagnetic waves with wavelengths that range from 5.6 to 1,000.0 μm.

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Infrared radiation transfers energy that is perceived as heat by thermoreceptors in the surrounding skin [2]. FIR therapy improves skin blood flow [3]. FIR therapy also improves endothelial function and reduces the frequency of some cardiovascular diseases [4–6]. Vascular access dysfunction is a major problem in HD patients. FIR radiation is a novel therapy that reported to improve the unassisted patency at 1 year in the patients with AVF population [7]. Lin et al [8] reported that FIR therapy improves the blood flow, maturation, and patency of a newly created AVF in patients with stage 4–5 chronic kidney disease. The aim of the present study was to evaluate the effects of FIR therapy on vascular access blood flow (Qa) and needling pain in HD patients.

Methods

Study design

This was a prospective clinical trial conducted from June 2013 to July 2014 at Soonchunhyang University Bucheon Hospital. All enrolled patients were maintained with 4 hours of HD 3 times/wk in our clinic. Eligible patients were those who either had no history of percutaneous transluminal angioplasty (PTA) or had undergone ≥ 1 PTA procedures, with the last PTA procedure successfully performed within 1 week before enrollment. We excluded patients who underwent HD treatment at a frequency other than 3 times/wk, had previously undergone FIR radiation therapy, had missed more than 10% of FIR treatments, had a history of kidney transplantation, were switched to peritoneal dialysis, or had severe disease with an estimated life expectancy of < 1 year. Data relevant to baseline characteristics [age, sex, HD therapy duration, PTA history, presence or absence of diabetes mellitus (DM), hypertension, liver disease, coronary artery disease, cerebrovascular disease, peripheral arterial disease, and medications] and patency outcomes were observed.

Patients provided written informed consent before beginning the study. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Soonchunhyang University Bucheon Hospital Institutional Research Board.

FIR radiation therapy

FIR therapy was performed for 40 minutes during each HD session. We started FIR therapy within 30 minutes after starting HD. Specialized FIR emitters (WS TY-101N; WS Far Infrared Medical Technology Co., Ltd., Taipei, Taiwan) were used for FIR therapy. Electrified ceramic plates were positioned approximately 25 cm above the skin surface at the needling site. The irradiating power density was about 10 and 20 $\mu W/cm^2$ when the radiator was set at a distance of 30 and 20 cm above the skin surface, respectively. Radiation therapy was continued in every HD session.

Measurement of Qa and pain

Qa was monthly measured within 2 hours after start of HD. Measurement was performed by the ultrasound dilution method using a Transonic HD03 HD monitor (Transonic Systems, Ithaca, NY, USA) [9]. Qa was measured before and after intervention in patients with FIR therapy. Needling pain and anxiety in patients were measured with a numeric rating scale. The scale indicated pain severity on a scale of 0–10 points, which correlated with no pain and uncontrolled severe pain, respectively.

The mean baseline Qa and pain were obtained during the 1 week before the start of the study. These parameters were then recorded at months 1, 3, 6, and 12 after beginning the study.

Study protocol

Effect of FIR therapy in a single HD session

We measured the study participants' Qa, body temperature (BT), and pain and anxiety scores before and after FIR therapy. The patients scored their own pain and anxiety. The nurse checked the patients' skin status in terms of inflammation, burning, or other abnormalities; sense of itching before needling; bleeding site during HD; and time required for hemostasis.

Effect of 1 year of FIR therapy on Qa and unassisted patency

We measured the study participants' Qa, BT, and pain and anxiety scores before and at months 1, 3, 6, and 12 after the start of the study. The primary outcome was the unassisted patency, which was defined as the time from study commencement to the first episode of AVF malfunction. We defined AVF malfunction as the need for any interventional procedure (surgery or angioplasty) to correct an occlusive or malfunctioning AVF that could not sustain an extracorporeal blood flow of > 200 mL/min during HD.

To analyze the effect of Qa and unassisted patency, we compared the study participants who underwent 1 year of FIR therapy with control patients who received no intervention for their access site during the study period. We matched the controls and participants by age, sex, and presence of DM.

Statistical analysis

Statistical differences in clinical characteristics and Qa per month between the 2 groups were evaluated using the χ^2 test or Fisher's exact test for categorical variables and Student's t test or the Wilcoxon rank-sum test for numerical variables. Univariate and multivariate Cox proportional hazard regression analyses were conducted to determine the predictors of unassisted patency survival. The survival probability of unassisted patency was estimated according to the Kaplan–Meier method, and survival curves were compared with the log-rank test. The Wilcoxon signed-rank test was used to compare differences in Qa between pre- and post-FIR therapy. All statistical analyses were performed using SAS software (version 9.4 for Windows; SAS Institute, Inc., Cary, NC, USA). The statistical significance level was set at $P < 0.05$ (2-tailed).

Results

Twenty-five HD patients (mean age, 52.6 ± 10.7 years; 40% female) were enrolled in FIR therapy and other 25 HD patients were matched as control after the study. Table 1 compares the baseline characteristics between the FIR therapy group and control group. The clinical baseline characteristics were similar in both goups with the exception of treatment with calcium channel blockers and anticoagulation agents.