Clinical Nephrology, Vol. 78 – No. Suppl. 1/2012 (S34-S36)

clinical nephrology

Original

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ISSN 0301-0430

DOI 10.5414/CNX77S105
e-pub: ■■■

Effects of high-tone external muscle stimulation on renal function in healthy volunteers

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Key words
electrotherapy – glomerular filtration rate – renal sodium transport

Abstract. Objective and design: High-tone external muscle stimulation (HTEMS) ameliorates pain and discomfort of patients with polyneuropathy. Since some patients reported about an urge to urinate during these treatments, the potential effects of HTEMS application on renal function were investigated. For this purpose in healthy subjects, we analyzed in the current study the acute effects of electrotherapy on parameters of renal function. Interventions: 24 healthy volunteers (14 women and 10 men), mean age 26 ± 4 years, were enrolled. The protocol was composed of a run-in period, a pre-treatment period, the active HTEMS treatment period of both lower extremities and the post-treatment period. The duration of each period was 60 min. Urine collection and blood samples were taken at the beginning and end of each period. To achieve a sufficient diuresis, the fluid intake was adapted to the amount of diuresis. Parameters of renal function included diuresis, glomerular filtration rate (endogenous creatinine clearance) and absolute and fractional sodium excretion. Moreover blood pressure and heart rate were monitored. Results: HTEMS led to a significant increase of creatinine clearance and fractional sodium excretion which was limited to the active treatment period. Conclusion: These findings show for the first time that HTEMS can transiently increase glomerular filtration rate associated with a decreased tubular sodium reabsorption. The underlying mechanisms are to be elucidated.

Received
■■■;
accepted in revised form
■■■

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Introduction

Various forms of electro-medical therapy are used in pain management [1, 2, 3]. Recently, "high-tone external muscle stimulation" (HTEMS) has been developed as a new kind of electrotherapy technique [4, 5]. HTEMS uses carrier frequencies between 4,096 to 32,768 Hz in short intervals [4]. Recently an analgesic effect of HTEMS treatment in patients with diabetic neuropathy [4] as well as in patients with end-stage renal disease (diabetic and/or uremic peripheral neuropathy) was demonstrated [5]. Our observation of an urge to urinate in some patients with diabetic neuropathy during HTEMS therapy (unpublished data) led us to study the acute effect of electrotherapy on parameters of renal function. Other hints about potential diuretic effects of electrotherapy were observed in experiments with rats with ischemic acute renal failure where a direct application to the kidney was performed [6]. However, there are no data regarding the influence of electromyostimulation on renal function in man.

Our objective therefore was to determine whether HTEMS influences urinary flow rate, glomerular filtration rate and tubular transport of sodium in healthy volunteers in a one-time study.

Methods

A prospective non-randomized, clinical pilot study was performed in healthy volunteers in the Nephrological Ward of the Department of Internal Medicine (University Hospital Motol, Prague, Czech Republic). 24 healthy participants (14 women and 10 man), aged between 22 – 37 years (26 SD ± 4 years), BMI 23 ± 3 kg/m^2 were enrolled.

External muscle stimulation was performed with a 230-V power-supply device (HiTop191 appliance, gbo Medizintechnik, Rimbach, Germany). Electrodes were placed on both femoral muscles. The intensity of the HTEMS treatment used was 168 (154 – 176) mA.

Table 1. Effect of HTEMS on renal function in healthy subjects.

	HTEMS on-time treatment (n = 24)			ANOVA
Time period	t1	t2	t3	p
Urinary flow rate (Ml/min)	5.7 ± 3.5	6.8 ± 4.2	5.4 ± 3.3	0.36
Urinary Na excretion (mmol/min)	0.9 ± 0.7	1.0 ± 0.9	1.2 ± 1.0	0.59
Creatinine clearance (Ml/min/1.73 m^2)	136.5 ± 27.6	168.7 ± 41.9*	140.8 ± 43.9	0.01
FE_{Na} (%)	0.9 ± 0.4	1.2 ± 0.5*	1,1 ± 0.4	0.04

HTEMS: High-Tone External Muscle Stimulation; t1: pre-treatment period; t2: treatment period; t3: post-treatment period; FE_{Na}: fractional sodium excretion.

The intensity of electrical stimulation was adjusted appropriately to the comfort level of each individual participant, without producing discomfort or pain. All subjects were treated for 1 h. Fluid intake in the course of study was adapted to the amount of urine from the preceding collecting period. The primary aim of the study was to evaluate the potential modulation of glomerular filtration rate (GFR) estimated as endogenous creatinine clearance (C_{Cr}) and renal sodium transport estimated as fractional sodium excretion (FE_{Na}). Furthermore, diuresis and urinary sodium excretion were measured. Other recorded parameters during procedure included systolic and diastolic blood pressure and heart rate.

Laboratory methods

Biochemical examination of blood and urine samples included serum and urine electrolyte concentrations, serum and urine creatinine (enzymatic methods). All examinations were performed using the ADVIA 1800 analyzer (Siemens Medical Solutions, Tarrytown, New York, USA).

Written informed consent was obtained from all the participants. The study was approved by the Ethics Committee of the University Hospital Motol, Prague, according to the declaration of Helsinki.

Statistical methods

Data are expressed as mean ± SD. The changes in the examined parameters were calculated by the ANOVA test using Stat View SAS Institute Inc.

Results

The results of urinary flow rate, sodium excretion, C_{Cr}, and FE_{Na} in pre-treatment, treatment and post-treatment period are summarized in Table 1. There was a significant rise of C_{Cr}, and FE_{Na}, while the urinary flow rate showed only a trend to higher values. Also the changes in urinary Na excretion were not significant. No significant changes in systolic and diastolic blood pressure and heart rate were observed during the study.

Discussion

In our study of healthy volunteers, HTEMS treatment resulted in a significant transient increase of creatinine clearance and fractional sodium excretion. This finding suggests that HTEMS can transiently increase glomerular filtration rate and decrease the tubular sodium transport. Changes of glomerular filtration rate are very likely caused by an increase of renal blood flow and might be explained by the influence of vasodilating factors including an enhanced NO formation. Our assumption of an augmented renal blood flow after HTEMS application is supported by the observation of other authors that transcutaneous electrical nerve stimulation (TENS) increased the microcirculation of the intact skin in healthy volunteers [7]. Moreover, improved circulatory effects of TENS have been described in patients with severe angina pectoris [8]. TENS also exerts blood pressure lowering effects in patients with drug resistant hypertension [9]. In our study the average values of diuresis were not statistically different among observed periods. There was only a trend to higher values. It has to be underlined that our investigation was performed in healthy subjects. In contrast to this situation in patients with chronic pain elevated blood levels of vasopressin have been described [10]. Therefore, it is conceivable that our clinical observation of the enhanced diuresis during HTEMS treatment of patients with painful neuropathy may be a consequence of a lowered anti-di-

uretic hormone levels. Based on this background, additional studies of electrotherapy in patients with chronic pain are of interest.

Conflict of interest

The authors disclose any relationship with industry and financial associations that might pose a conflict of interest with the submitted article.

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