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Effects of bilateral T2-sympathectomy on static and dynamic heart rate responses to exercise in hyperhidrosis patients

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Abstract

The static/dynamic changes of gas exchange, heart rate (HR) and blood pressure in terms of work rate (WR) and WR changes in ramp exercise were investigated by cardio-pulmonary exercise tests (CPETs) in hyperhidrosis patients before (W0), one week (W1) and four weeks (W4) after bilateral T2-sympathectomy. Accompanied by constant oxygen consumption and WR at peak exercise and similar oxygen debt in recovery, the HR significantly ($p<0.05$) decreased statically in all stages of CPET, but was not altered dynamically, i.e., similar slope but significantly diminished intercept in HR changes versus WR changes (70 ± 6.0 vs. 82 ± 19 beats/min, $p<0.01$), in W1 ($n=11$), compared to W0 ($n=13$). However, this surgical effect on static HR changes seemed to have disappeared in W4 ($n=8$), albeit at that time the static blood pressure decreased significantly during exercise. These findings suggest that bilateral T2-sympathectomy will reduce static HR without causing cardiovascular insufficiency in one week, and would then recover by one month in hyperhidrosis patients.

Keywords: Autonomic nervous system; Endoscopic transthoracic sympathectomy; Sympathetic cardiac nerve; Gas exchange; Hemodynamics

1. Introduction

Endoscopic thoracic (T)-sympathectomy, with resection or destruction of sympathetic ganglia from the second (T2) to the fifth (T5) thoracic segments, is accepted as an appropriate surgical intervention for treating palmar hyperhidrosis (Noppen et al., 1995). However, a decrease in heart rate (HR) at rest and during maximal exercise has been reported after surgery (Drott et al., 1994; Noppen et al., 1995). To minimize postoperative morbidity and to shorten thermocoagulation time, the modified bilateral T2-sympathectomy, the procedure of excising bilateral T2 sympathetic ganglia and ablating their accessory nerve, has successfully treated essential hyperhidrosis of the palm (Chiou and Chen, 1999; Chuang and Liu, 2002). However, few studies have investigated potential changes in resting and exercise-related cardiopulmonary parameters after the modified bilateral T2-sympathectomy.

The sweat glands in the upper extremities are innervated by sympathetic fibers arising from the T2–T9 segments, which supply the preganglionic sudomotor fibers via white rami communicantes to the upper dorsal ganglia at the level of the lower cervical to the T1 and T2 segments. The postganglionic fibers pass through gray rami communicantes to the C5–T1 roots of the brachial plexus (Johnson and Spalding, 1974). Meanwhile, the cardiogenic sympathetic nerves from the brainstem, innervating T2–T6 ganglia, project to the heart.

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Generally, HR may be regulated by the interaction between the sympathetic outflow arising from T2–T6 intermediolateral gray neurons and the parasympathetic counterpart from the ambiguous and dorsal motor nucleus (Malpas, 1998). Moreover, in animal studies, successive sections of the thoracic white rami from the C5–T1, to reduce active postganglionic fiber numbers, gradually decreased peak amplitude and width of total cardiogenic sympathetic nervous activities (Ninomiya et al., 1993). A significant decrease in resting and maximal exercise HR has been reported after treating isolated palmar hyperhidrosis with endoscopic resection of sympathetic ganglia at the T2–T5 levels (Drott et al., 1994; Noppen et al., 1995). Besides, HR, arterial blood pressure, and serum levels of catecholamine decreased at rest and during submaximal treadmill exercise after T2–T3 endoscopic transthoracic sympathectomy (Nakamura et al., 2002). Therefore, dynamic cardiovascular functions, related to cardiogenic sympathetic tone, might change after a bilateral T2-sympathectomy for treating palmar hyperhidrosis, though little research has addressed it.

In the present study, cardiopulmonary exercise tests (CPETs) were used to evaluate the effects of a bilateral T2-sympathectomy on static and dynamic cardiac responses in hyperhidrosis patients and to demonstrate the surgical effects on metabolic and cardiovascular functions.

2. Materials and methods

Eligible subjects (10 males and 3 females, aged 22.4 ± 7.7 years, 61.8 ± 11.0 kg in body weight; Table 1) enrolled in this study. All protocols were reviewed and approved by the Institutional Review Board of Chung-Shan Medical University Hospital in Taichung, Taiwan. All participants suffered from essential palmar hyperhidrosis, refractory to local, systemic and/or iontophoretic treatments. They were non-smokers and free from any cardiovascular, pulmonary, metabolic or neurological disease.

A single stage bilateral endoscopic trans-axillary T2-sympathectomy was performed under general anesthesia as described previously (Chiou and Liao, 1996). After standard endotracheal intubation, patients were placed in a semi-reclining position, and the endoscopic instruments were set up. The T2-ganglion and its accessory fibers were completely electro-coagulated along the upper border of the third rib. All patients had day surgery and went home. Patients were checked at one week and four weeks after the surgery, at which times CPETs were completed.

Each participant received three CPETs with identical protocol: one or two days before (W0), one week (W1) and four weeks (W4) after the operation. The CPET was performed as follows: 3 min rest, followed by a 3-min unloaded pedaling period, a ramp test, and a 4-min recovery stage (unloaded pedaling again). The increased work rate (WR) (ranged 15–20 W/min) was chosen so that the subject would be exhausted after around 10 min of ramp exercise at a progressively increasing WR. During testing, the parameters of gas exchanges, including exhaled ventilatory volume per min ($\dot{V}E$), oxygen uptake per min ($\dot{V}O_2$), and carbon dioxide output per min ($\dot{V}CO_2$) were measured breath by breath. Cardiovascular parameters including blood pressure (by using an autonomic blood pressure cuff; Tango, Sun Tech Medical Instruments Inc, Raleigh, NC USA), O_2 saturation (Invivo 4500 plus, Invivo Research Inc. USA) and HR from 12-lead electrocardiographs (Marquette CardioSys v 3.01) were recorded simultaneously. All of these signals were relayed to a digital recording system (Vmax229d Cardiopulmonary Exercise Testing Instrument; SensorMedics, Yorba Linda, CA). Additionally, the derived variables, including respiratory exchange ratio, end tidal O_2 and CO_2 partial pressure, the ventilatory equivalents for $\dot{V}O_2$ and $\dot{V}CO_2$ as well as oxygen pulse (O_2P, i.e., oxygen uptake per min per heart beat) were all calculated off-line.

Table 1
Patient demographics

Patient no.	Gender	Age (yrs)	Height (cm)	Weight (kg)	Hb (mg/dL)	Hct (%)
1	F	16	159	57	12.9	36.8
2	M	16	167	45	13.2	39.0
3	M	21	175	64	14.7	44.4
4[a]	M	20	170	68	16.6	46.8
5[a]	M	43	167	85	15.3	42.8
6[a]	M	32	169	70	16.2	46.6
7	F	20	158	60	11.3	34.4
8	M	15	163	51	15.0	45.1
9	M	19	164	60	14.2	42.5
10[a]	M	18	180	71	15.0	45.4
11	F	25	163	45	14.2	41.7
12[b,a]	M	23	178	65	15.2	44.5
13[b]	M	23	174	63	16.1	46.4
Mean ± S.D.		22.4 ± 7.7	168 ± 7.0	61.8 ± 11.0	14.6 ± 1.5	42.8 ± 3.9

Definition of abbreviations: Hb = hemoglobin; Hct = hematocrit; F = female; M = male.
[a] Did not participate in cardiopulmonary exercise testing four weeks post T2-sympathectomy.
[b] Did not participate in cardiopulmonary exercise testing one weeks post T2-sympathectomy.