Original Article

http://dx.doi.org/10.3349/ymj.2012.53.6.1081
pISSN: 0513-5796, eISSN: 1976-2437

Yonsei Med J 53(6):1081-1084, 2012

YMJ

The Effects of Thoracic Sympathotomy on Heart Rate Variability in Patients with Palmar Hyperhidrosis

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Received: April 4, 2012
Revised: May 16, 2012
Accepted: June 11, 2012
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· The authors have no financial conflicts of interest.

Purpose: To observe the evolution of heart rate variability (HRV) in patients with palmar hyperhidrosis before and after endoscopic thoracic sympathotomy and to evaluate the effects of the surgery on the autonomic nervous system. **Materials and Methods:** Endoscopic thoracic sympathotomy was performed on 20 patients with palmar hyperhidrosis. The thoracic sympathetic chain at the level of the third to fourth rib (R3-R4) was transected, but the ganglia were left in position without removal. A slightly larger ramus, in comparison to the other rami, that arose laterally from the sympathetic chain was interrupted to achieve adequate sympathetic denervation of the upper extremity. Before and on the day after the surgery, 24-hour Holter Electrocardiograph was performed, obtaining time domain and frequency domain parameters. **Results:** Compared with preoperative variables, there was a significant increase in the number of adjacent normal R wave to R wave (R-R) intervals that differed by more than 50 ms, as percent of the total number of normal RR intervals (pNN50); root mean square difference, the square root of the mean of the sum of squared differences between adjacent normal RR intervals over the entire 24-hour recording; standard deviation of the average normal RR interval for all 5-minute segments of a 24-hour recording (SDANN) after thoracic sympathotomy. Low frequencies (LF, 0.04 to 0.15 Hz) decreased significantly. There was no statistical difference in high frequencies (HF, 0.15 to 0.40 Hz), LF/HF ratio (LF/HF), or standard deviation for all normal RR intervals for the entire 24-h recording (SDNN) before and after thoracic sympathotomy. **Conclusion:** There was a significant improvement in HRV in patients with palmar hyperhidrosis after thoracic sympathotomy. This may be attributable to an improvement autonomic nervous system balance and parasympathetic predominance in the early postoperative stage.

Key Words: Sympathotomy, hyperhidrosis, heart rate, autonomic nervous system

INTRODUCTION

Palmar hyperhidrosis, a type of primary hyperhidrosis without a known etiology, is characterized by excessive sweating of the palms and often the armpits. It has been associated with dysfunction of the sympathetic nervous system.[1] Ablation of the upper thoracic sympathetic chain (endoscopic thoracic sympathotomy) has proven to be a minimally invasive and effective treatment for which to permanently abolish palmar hyperhidrosis, refractory to conservative modalities.[2,3] However, from a location where sympathetic fibers that innervate the heart and lungs are derived, sympathetic fibers to the exocrine glands of the palms of the hands also arise from the cervicalis and upper thoracic ganglia.[4,5] Thus, transection of the upper interganglionic branches may also interrupt the conduction of the heart sympathetic nervous system.

Accordingly, a few studies have shown that thoracic sympathotomy may influence cardiac and pulmonary function.[6-8] The authors of those studies attributed this observation to a change in the activity of the autonomous nervous system, but without convincing evidence.

The aim of the study was to investigate the evolution of heart rate variability before and after thoracic sympathotomy and to assess the effects of the surgery on autonomic nerve system balance.

MATERIALS AND METHODS

Study population

Between January 2007 and August 2009, a prospective study of endoscopic thoracic sympathectomies for palmar hyperhidrosis was undertaken. Twenty patients (12 males and 8 females) with severe bilateral palmar essential hyperhidrosis (some combined with axillary hyperhidrosis) with a mean age of 22.4 (range, 18-35) years were included in the study. Diagnosis of primary palmar hyperhidrosis was mainly based on case histories and exclusions of secondary hyperhidrosis. Most patients reported childhood onset of excessive sweating of the palms of the hands and exacerbation of symptoms during puberty and adolescence. In most cases, symptoms were aggravated by emotional factors and heat. None of the patients was under medication two weeks prior to the study.

Surgical procedure

Patients were place in the supine position with 30-40° anti-Trendelenburg tilt of the surgical table. Under general anesthesia with single lumen tracheal intubation, the patient's arms were abducted to expose the axilla. The procedure was performed with two ports: an 8 mm port at the mid-axillary line at the fifth intercostal space for the introduction of telescope, and a 5-10 mm port at the anterior axillary line at the third intercostal space for working instruments. After identification of the second, third and fourth ribs, the parietal pleura were opened with a diathermy hook at the level where the sympathetic chain crossed the ribs. The sympathetic chain was cauterized and transected at the level of R3 and R4, and the communicating rami were gently cauterized and transected completely, leaving the ganglia in position without removal. The lung was inflated after the procedure under direct vision to confirm that it was well expanded.[9]

Monitor the 24-hour Holter ECG

To analyze heart rate variability and interpretation, 24-hour Holter Electrocardiobram (ECG) was performed in all patients on two or three days before and on the first day after endoscopic thoracic sympathotomy. A twelve-lead digital ECG recorder equipped with a Holter analyzer (MARS Holter Analysis Workstation, GE MEDICAL SYSTEMS INFORMATION TECHNOLOGIES) was used, with the sampling frequency of 250 Hz. Supraventricular and ventricular ectopic beats, as well as artifacts, were identified and manually eliminated from the analysis.[10] Long-term time domain and frequency domain variables from 24-hour recordings were analyzed. The time domain variables included the following: 1) SDNN, standard deviation of all normal R-R intervals over the entire 24-hour recording; 2) SDANN, standard deviation of the average normal R-R interval for all 5-min segments of a 24-hour recording; 3) root mean square differencer (rMSSD), the square root of the mean of the sum of squared differences between adjacent normal R-R intervals over the entire 24-hour recording; and 4) pNN50, the number of adjacent normal R-R intervals differing by more than 50 ms, as a percent of the total number of normal R-R intervals. In addition, the following frequency domain parameters were analyzed: very low frequency (VLF, 0.003 to 0.04 Hz); low frequency (LF, 0.04 to 0.15 Hz); high frequency (HF, 0.15 to 0.40 Hz); and LF/HF ratio.

Statistical analysis

The data are expressed as mean±standard derivation (SD). Statistical software SPSS version 13.0 (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. Comparisons of heart rate variability before and after surgery were performed using two-tailed, paired-Student's t-tests. *p*-values of <0.05 were considered statistically significant.

RESULTS

Endoscopic thoracic sympathotomy was performed in 20 patients. The mean recording time was 22.8±1.2 hours (mean±SD). All patients exhibited immediate cessation of palmar hyperhidrosis, without severe complications, such as pneumothorax, hemothorax, atelectasis, Horner Syndrome, prolonged pain, and so on.

Compared with preoperative variables, a significant increase in pNN50, rMSSD, SDANN ($p<0.05$) and a remarkable decrease in LF ($p<0.05$) was observed after endoscopic thoracic sympathotomy. There was no significant difference in HF, LF/HF, or SDNN before and after thoracic sympathotomy (Table 1).

DISCUSSION

The preganglionic fibers traveling to the upper limb come mainly from the intermediolateral nucleus lacated in the spinal cord lateral horns of the T2-T8 spinal segment, leave the cord at the anterior rootlets of the thoracic nerves, go through the white rami communicates, the ventral roots, and the front branches, enter the sympathetic trunk and then synapse, and then finally reach their target postganglionic neurons in the paravertebral or prevertebral thoracic sympathetic ganglia. The postganglionic fibers traveling to the upper limb originate from different ganlions, including the middle cervical ganglion, the stellate ganglion and upper thoracic ganglia; join the thoracic nerves through the gray communicanting rami; enter the brachial plexus; and then travel along different nerves to their end targets. Theoretically, ramicotomy of the white rami communicantes, including the second to the eighth thoracic nerves and the sympathetic trunk could lead to successful sympathetic surgery for treating upper essential hyperhidrosis.[11] The aim of surgical treatment of primary hyperhidrosis is to interrupt the thoracic sympathetic chain at the R3-R4 level by resection or electrocautery. However, sympathetic fibers that innervate the heart, lungs and other thoracic viscera are also present along the exact same pathway. Therefore, from the theoretic perspective, sympathotomy may impair the sympathetic nervous system that innervates the heart and lungs, altering sympathetic or parasympathetic dominance in the autonomic nervous system.

In the present study we studied the effect of endoscopic transthoracic sympathotomy (ETS) on the autonomic nerve system via heart rate variability (HRV), which is a non-invasive, semi-quantitative assessment of the activity of the autonomic nervous system. Compared with the parameters before ETS, we observed a statistical significant increase in SDANN, reflecting an improvement in global cardiac autonomic activity; there was also a remarkable decrease in LF among frequency domain variables, indicating a sympathetic withdrawal. pNN50 and rMSSD were also significantly increased, suggesting increased vagal activity. However, we found no statistical difference in HF, LF/HF and SDNN before and after the surgery. Generally, such occurrences can be attributed to sympathetic withdrawal and a relative increase in parasympathetic activity after ETS.

Heart rate variability is a non-invasive, semi-quantitative assessment of the activity and balance of the sympathetic and vagal components of the autonomous nervous system. Among the statistical parameters, SDNN and SDANN which represent sympathetic and parasympathetic activity can be obtained from long-term records, but there's a weak point of not distinguishing whether increased sympathetic tone or withdrawal of vagal tone contribute to changes in HRV. The rMSSD and pNN50 indexes are representative of parasympathetic activity. In regards to the frequency domain parameters, HF, an indicator of the performance of the vagus nerve on the heart, corresponds to respiratory modulation; LF reflects the joint action of the vagal and sympathetic components on the heart, predominantly the sympathetic ones. VLF indexes are used less in heart rate variability assessment without physiological explanation. VLF seems to be involved in the renin-angiotensin-aldosterone system, peripheral vasomotor tone and thermoregulation. LF/HF ratio is a sign of sympathetic-vagal balance on the heart re-

Table 1. Parameters of Heart Rate Variability before and after Endoscopic Thoracic Sympathotomy

	LF (ms^2/Hz)	HF (ms^2/Hz)	LF/HF	SDNN (ms)	SDANN (ms)	rMSSD (ms)	pNN50 (%)
Before surgery	6.7±0.8	4.4±0.6	1.5±0.4	98.3±15.3	63.6±25.6	36.3±13.7	6.3±4.3
After surgery	5.1±0.6	4.2±0.7	1.2±0.3	107.2±32.6	93.2±32.6	57.1±21.5	19.7±8.9
p value	0.015	0.059	0.552	0.123	0.038	0.023	0.008

LF, low frequencies; HF, high frequencies; rMSSD, root mean square difference; SDANN, standard deviation of the average normal RR interval for all 5-min segments of a 24-hour recording; SDNN, standard deviation for all normal RR intervals for the entire 24-hour recording.

flecting the relative and absolute changes between the sympathetic and parasympathetic components of the autonomic nervous system.

Wiklund, et al.[12] also found that after sympathotomy LF power was reduced, but HF power did not change. In addition, they observed that LF power remained at a lower level, while HF power was reduced at follow-up, approximately six months later. They came to the conclusion that sympathotomy resulted in an initial sympathovagal change with parasympathetic predominance, which was restored on a long-term basis. These observations also support the sympatholytic effect of the surgical procedure.

A few studies have shown significant effects for thoracic sympathotomy on cardiac and pulmonary function variables. Cruz, et al.[13] observed a statistically significant decrease in forced expiratory flow,[14] airway resistance in small airways, an increase in residual volume, and a significant decrease in heart rate and ejection fraction, even though the parameters were all in normal ranges. Nakamura, et al.[15] verified that HR and arterial blood pressure decreased at rest and during submaximal treadmill exercise after R2-R3 endoscopic transthoracic sympathotomy. In addition, they also identified an increase in plasma adrenaline and noradrenaline after ETS. Tedoriya, et al.[16] found that responses to the sympathetic stress were suppressed by ETS. The cardiopulmonary effects of ETS are probably a consequence to the removal of the R2 to R4 adrenergic cardiopulmonary efferent or afferent section during surgery.

In summary, there was a significant improvement in HRV in patients with palmar hyperhidrosis disease after thoracic sympathotomy. This may contribute to a shift in sympathovagal unbalance toward parasympathetic dominance in the early stage after endoscopic transthoracic sympathotomy. The lack of long-term follow-up and the measurement of plasma catecholamine concentration are limitations of our study. Further study should be taken to identify the value of HRV as a predictor of long-term treatment effects.

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