Influences of bilateral endoscopic transthoracic sympaticotomy on cardiac autonomic nervous activity

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Abstract

Objectives: Endoscopic transthoracic sympaticotomy (ETS) is a minimal invasive procedure of thoracic sympathetic blockage. The purpose of this study was to evaluate cardiac autonomic nervous activity after ETS in order to confirm the reliability and safety of ETS.

Methods: A series of electrophysiological studies were performed before and 1 week after bilateral 2nd and 3rd thoracic sympaticotomy in 13 patients with primary palmar hyperhydrosis. Palmar perspiration was measured under sympathetic stress, and body surface mapping was recorded in a supine position. In the head-up tilt test of 0, 30, 60 and 90°, corrected QT interval (QTc) and T wave amplitude (Twa) were assessed. The power spectral analysis of heart rate variability was processed to attain power values of the low-frequency (0.04–0.15 Hz), the high-frequency (0.15–0.40 Hz) and the low/high frequency ratio. Results: In all patients, the perspiration response on the palm to sympathetic stimulation was completely inhibited after ETS. Isointegral mapping revealed that ETS altered electroactivity on the heart. In the head-up tilt study, R–R intervals significantly increased after the surgery in the head-up tilt positions (P < 0.05), although there was no significant difference in the supine position. There is no significant difference in QTc and Twa before and after the surgery, both in the supine and the head-up tilt positions. There was no significant difference in the LF or HF before and after surgery, either in the supine position or the head-up tilt positions. In the LF/HF, there was no significant difference before and after surgery in the supine position. However, the LF/HF in the head-up tilt positions was significantly decreased after surgery (P < 0.05). Sympathetic suppression of ETS was recognized more obviously under the steeper head-up tilt positions. Conclusions: The influences on the cardiac autonomic nerve system of the ETS of upper thoracic sympathetic nerve were seen to be of a lesser degree at rest. However, the response to sympathetic stimulation was suppressed after the surgery. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Endoscopic transthoracic sympaticotomy; Heart rate variability; Cardiac autonomic nervous activity; Electrophysiology

1. Introduction

Thoracic sympathectomy has been performed for hyperhydrosis of the palm, peripheral vascular insufficiency, and Raynaud’s phenomenon [1,2]. The results of thoracic sympathectomy using conventional methods had been acceptable, but due to the magnitude of the procedure, the surgical operation has not been widely performed. Claes et al., have developed a simple endoscopic procedure employing electrocautery of the thoracic sympathetic ganglia [3–5]. Since the cardiac autonomic nervous system is influenced to a degree by the upper thoracic sympathetic nerve, the effect of ETS on the heart must be investigated closer [2,6]. In order to assess the effect of ETS for the upper thoracic sympathetic nerve on cardiac autonomic nervous activity, an electrophysiological study was performed on patients with palmar hyperhydrosis before and after ETS.

2. Material and methods

2.1. The ETS procedure

Thoracoscopy was performed under general anesthesia with a standard single-lumen endotracheal tube with the patients in a semi-sitting position. The pleural cavity was...
punctured at the 2nd intercostal at anterior axillary line with an atraumatic canula. Insufflation was performed with 1.5 l of carbon dioxide(CO₂). A modified Karl–Storz urological electroresectoscope was introduced into the pleural cavity through the same incision. The sympathetic chain was identified the proximity of the costovertebral junction. The ganglia lying over the ribs were cauterized with coagulation-strength current and completely divided. Bleeding from surrounding vessels can be controlled easily using loop, or ball-type electrodes. After evacuation of the gas, the wound was closed without the insertion of any drainage tubes.

We assessed the influence of ETS on cardiac autonomic nerve activity prior and following surgery in 13 patients who had primary palmar hyperhidrosis, but were free of other diseases including cardiac disease. Of these, eight males and five females with a mean age of 25 ± 10 years old, ranging from 15 to 44. All of the study was performed before and 1 week after surgery.

Perspiration output from the palm was measured with a continuous sweat output analyzer, Kenz Perspiro OSS-100 (Suzuken, Tokyo, Japan) under physiologic and neural stress in patients with hyperhidrosis prior to and following to the surgery. This machine is a simple apparatus for continuous recording of perspiration rate utilizing a hygrosensor of electrostatic capacity type [7]. The probe was settled on the surface of thumbs of patients in a sitting position. After a few minutes in the condition of rest, three types of sympathetic stress, deep breathing as a physiologic stress and reversed recitation of four numbers and repeated subtraction (100 – 7 – 7 – ...) as neural stresses were examined.

Body surface mapping was recorded at 87 points in a supine position before and after the surgery. The maximum amplitude of the T wave on electrocardiogram (Tmax) was calculated. The largest value (Iso-max) and the smallest value (Iso-min) attained through isointegral mapping were calculated.

Head-up tilt test was performed before and 1 week after the surgery. The inclination of the electrical driven table was varied at the following angle: 0, 30, 60, 90°. Each position was maintained for 10 min. After each position, inclination was returned to horizontal position for 10 min. During this procedure, 12 leads-ECG was recorded continuously. Corrected QT interval (Qtc) and the T wave amplitude (Twa) were measured in II lead. The change in heart rate variability was assessed by calculating the data of R–R intervals. The signal of V5 lead-ECG was input directly to the computer (PC-9801, NEC, Tokyo, Japan) using an analog–digital converter. The instantaneous heart rates during the 10-min periods were processed by a maximum entropy method algorithm using the software HPS-RRA (Fukuda Denshi, Tokyo, Japan), which yielded 512 consecutive R–R intervals for the 0.01–1.00 Hz frequency band. After this process, the following frequency domain indexes of heart rate variability were calculated (1) a power of the low-frequency component from 0.04 to 0.15 Hz, in (beats/min)² (2) a power of the high-frequency component 0.15–0.40 Hz, in (beats/min)² (3) the low frequency/high frequency power ratio [5].

Values are given as the median (minimum, maximum).

The Wilcoxon signed ranks test was used for comparisons between pre- and postoperative values. The intragroup comparisons with the control data (the supine position) in the head-up tilt study were made by Bonferroni/Dunn method. The level of significance was set at P < 0.05.

3. Results

The excessive perspiration on the palms disappeared after ETS in all the patients of this study. They had no surgical complication and did not recognized any symptoms on circulatory condition after the surgery.

3.1. Perspiration on palm

Prior to the surgery, spikes in sweat output were noted in responses to all stimulation (Fig. 1). However, following the surgery, all the sympathetic nervous response was completely ablated in all the patients as with the patient shown in Fig. 1. This means that ETS could lead to functional blocking of the 2nd and 3rd thoracic sympathetic nerve according to the distribution of the thoracic sympathetic nervous system [8].

3.2. Body surface mapping

Tmax was decreased after ETS from 6.8 (2.4, 10.2) to 5.9 (2.2, 9.6) mm (P = 0.03). ETS decreased Iso-max from 118 (44, 225) to 104(48, 202) mm × Ems (P = 0.04), and also Iso-min from –58 (–85, –22) to –50 (–74, –28) mm × Ems (P = 0.04). Iso-max points and Iso-min points were transferred after ETS in six patients (35%) and in seven patients (42%), respectively.

3.3. Head-up tilt test

There was no significant difference in the R-R interval in supine position between pre- and postoperative values. However, in the head-up tilt positions, R-R intervals increased significantly after the surgery. There is no significant difference in QTC between before and after the surgery in a supine and the head-up tilt positions. The Twa in the supine position was decreased after the surgery, from 0.70 (0.48, 0.99) to 0.51 (0.26, 0.77) mV. Although this tendency was recognized in the head-up tilt positions, the differences did not reach to the statistic ones (Table 1).

There was no significant difference in the both LF and HF components of the power values of the heart rate variability, in the supine position and the head-up tilt positions. The LF/ HF in the supine position was 1.03 (0.52, 2.21) before and 1.00 (0.45, 2.28) after the surgery. There is no significant
difference between these values. However, the LF/HF in the head-up tilt positions was significantly decreased after the surgery. Sympathetic suppression of ETS were recognized more obviously under the steeper head-up position as more stress for sympathetic system (Table 2).

Before ETS, R-R interval was significantly decreased in a 60° (P = 0.02), and in a 90° head-up position (P = 0.01, P = 0.01, respectively) in comparison with the supine position. There was no significant intragroup difference in LF. Following ETS, HF and LF/HF were also recognized with significant differences in a 60° (P = 0.01, P = 0.01, respectively), and in a 90° head-up position (P = 0.01, P = 0.01, respectively). There was no significant intragroup difference in LF after ETS.

4. Discussion

Thoracic sympathectomy for an autonomic disorder like primary hyperhydrosis was performed first by Kotzareff in 1920 using open surgery [5]. The effect of thoracic sympathectomy have since been fairly well described but, due to the magnitude of the procedure, this kind of surgery has not been commonly performed. Kux described, in 1954, a method of thoracoscopic electrosurgery of the sympathetic nerve, which however, did not gain widespread popularity. Claes et al., described a further simplification of thoracoscopic thoracic sympathicotomy in 1991 [3]. They reported the result of a ETS, that the effect of surgery was extremely satisfied, and there was no major surgical complication in 1274 procedures on 602 patients. Yilmaz et al., compared endoscopic thoracic sympathectomy with transaxillary approach [9]. They concluded that there was no difference in both of them in terms of efficacy.

Since 1992 we had been performing ETS with a modified method of Claes’s ETS, and had had no major surgical complication. ETS for the 2nd and 3rd thoracic sympathicotomy was performed using a standard single-lumen endотhoracical intubation and the artificial pneumothorax with CO₂. This procedure was very simple and brought an excellent operation view. Moreover, since the duration of the intrathoracic procedure was very short, the hemodynamics were stable. However, a single lung ventilation rather than CO₂ insufflation should be considered to be used for patients with any history or sign of cardiopulmonary problems, or for lower thoracic sympathicotomy.

Due to its simplicity and safety, ETS had been performed for further indications. Wettervik et al. [10] subsequently evaluated the antianginal effects of ETS, to reveal that ETS can be performed without major complications, it alleviates angina and increases the maximum working capacity in patients with advanced coronary disease. At the same time, ETS exerted an influence on cardiac autonomic nervous activity to a degree. The purpose of this study was to evaluate the influence of ETS on cardiac autonomic nervous system with various kinds of electrophysiological study, including power spectral analysis of heart rate variability. Moreover since this study was designed as an assessment of cardiac autonomic nervous system with various kinds of electrophysiological study, including power spectral analysis of heart rate variability. Therefore, it could also lead to indicate a kind of control data for analysis of cardiac autonomic study.

In this study, the continuous recording of sweating rate differences in a 60° (P = 0.02, P = 0.01, respectively), and in a 90° head-up position (P = 0.01, P = 0.01, respectively)
Table 1
Summary of the electrophysiological data on the head-up tilt test, before and after ETS. Data are shown as the median (maximum, minimum).

<table>
<thead>
<tr>
<th>Degree</th>
<th>RR (ms) Preop</th>
<th>RR (ms) Postop</th>
<th>QTc (ms) Preop</th>
<th>QTc (ms) Postop</th>
<th>TWA (mV) Preop</th>
<th>TWA (mV) Postop</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>964 (620, 1205) n.s.</td>
<td>997 (793, 1207) n.s.</td>
<td>406 (330, 482) n.s.</td>
<td>410 (372, 468) 0.70 (0.48, 0.99) P = 0.03 0.51 (0.26, 0.77)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>849 (602, 1227) P = 0.04 948 (707, 1195) 0.62 (0.29, 0.86) n.s.</td>
<td>355 (202, 492) n.s.</td>
<td>410 (366, 472) 0.43 (0.12, 0.82) n.s.</td>
<td>409 (358, 462) 0.38 (0.13, 0.77)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>722 (365, 1005) P = 0.02 835 (655, 1108) 0.43 (0.12, 0.82) n.s.</td>
<td>413 (365, 478) n.s.</td>
<td>409 (358, 462) 0.43 (0.12, 0.82) n.s.</td>
<td>409 (358, 462) 0.38 (0.13, 0.77)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>687 (548, 996) P = 0.01 780 (612, 1012) 0.44 (0.18, 0.77) n.s.</td>
<td>417 (362, 481) n.s.</td>
<td>413 (356, 477) 0.44 (0.18, 0.77) n.s.</td>
<td>413 (356, 477) 0.33 (0.12, 0.56)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n.s., Not significant; ETS, endoscopic transthoracic sympathicotomy; QTc, corrected QT interval; RR, the R-R interval; TWA, the maximum T wave amplitude.

Using a hygrosensor of electrostatic capacity was performed to reveal the status of sympathetic perspiration on palm before and following the surgery. This measurement system can indicate a very precise and quick response of perspiration. The results of this measurement showed that the ETS completely led to a functional blocking of sympathetic nerve activities in the palm immediately after the surgery.

The body surface mapping revealed that ETS minimally affected electrical activity on the myocardium. Although ETS did not affect QTc strongly in this study, it is very interesting to examine the influence of ETS on QTc in patients with long QT syndrome. There was no significant difference in the Twa as well, though a decreasing tendency after ETS was recognized in the supine and the head-up tilt positions. Although the R-R interval did not significantly elongate after ETS in the supine position, the rate of the R-R interval elongation was larger in the steeper inclined position, that means that ETS suppressed the response to the sympathetic nervous stimulation.

The cardiac autonomic nervous system conveys information that reaches the sinus node in the heart through efferent vagal and sympathetic pathways. The effect of these two autonomic influences is a beat-to-beat variability of the heart rate. For the assessment of cardiac autonomic control, frequency measurement of heart rate variability is developed clinically. Frequency domain, so-called power spectrum analysis, decomposes the sinus R-R interval signal into its frequency components and quantifies them in terms of ‘power’. Power spectrum analysis provided the suggestive evidence that heart rate variability reflects oscillations in sympathovagal balance. HF is considered to be a reflection of the vagal activity on the cardiac autonomic system, and LF/HF is considered to be a reflection of the cardiac sympathetic activity. The results of the spectral analysis of this study showed that the balance of the cardiac autonomic activity became vagal predominant after the ETS, especially, the response to the sympathetic stress was clearly suppressed by ETS. Ahmed et al., however, reported that the methods of heart rate variability analysis used are not specific for the measurement of sympathetic tone, defined as both sympathetic neural stimulation and effects of circulating beta-adrenergic agonists [11]. Conversely speaking, from the results of this study, since certain changes of the power spectral analysis of the heart rate variability were recognized in subjects who were completely confirmed with the functional blockage of the second thoracic sympathetic activity by means of the perspiration test on palm, this method indicates the cardiac autonomic nervous balance, and can be recognized as one of the useful and non-invasive methods for the cardiac autonomic nervous analysis. Furthermore, the results of this study are useful as control data for other cardiac autonomic study.

In conclusions, ETS is a safe and simple method of thoracic sympathetic nerve blockage, which was useful in the treatment primary palmar hyperhydrosis and ischemic disease of the upper extremities. The influences on the cardiac autonomic nervous system of the ETS of upper thoracic sympathetic nerve in patients without cardiac disease were seen to be of a lesser degree at rest, is spite that the response to sympathetic stimulation was suppressed after the surgery. Further assessment of the effect on cardiac autonomic activity with patients with circulatory problems will have to be studied.

Table 2
Summary of the heart rate variability on the head tilt-up test, before and after ETS. Data are shown as the median (maximum, minimum).

<table>
<thead>
<tr>
<th>Degree</th>
<th>HF (nm × Ems) Preop</th>
<th>HF (nm × Ems) Postop</th>
<th>LF (nm × Ems) Preop</th>
<th>LF (nm × Ems) Postop</th>
<th>LF/HF Preop</th>
<th>LF/HF Postop</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>898 (602, 2526) n.s.</td>
<td>951 (552, 2825) n.s.</td>
<td>605 (287, 2660) n.s.</td>
<td>681 (92, 2620) 1.03 (0.52, 2.21) n.s.</td>
<td>1.00 (0.45, 2.82)</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>262 (120, 1820) n.s.</td>
<td>246 (142, 2213) n.s.</td>
<td>566 (147, 1826) n.s.</td>
<td>416 (91, 1876) 3.12 (0.62, 6.21) P = 0.04 1.22 (0.62, 2.99)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>158 (58, 589) P = 0.04 230 (97, 1866)</td>
<td>509 (152, 1489) n.s.</td>
<td>358 (67, 1495) 8.61 (1.08, 22.12) P = 0.01 2.88 (0.66, 7.20)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>67 (37, 266) P = 0.04 125 (72, 402)</td>
<td>453 (126, 1322) n.s.</td>
<td>367 (62, 1405) 9.31 (1.26, 25.11) P = 0.01 4.95 (1.2, 9.29)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n.s., Not significant; ETS, endoscopic transthoracic sympathicotomy; HF, high frequency component; LF, low frequency component; LF/HF, the ratio of LF over HF.
References