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RESEARCH ARTICLE

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The body mass index and level of resection

Predictive factors for compensatory sweating after sympathectomy

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Abstract *Objective* Compensatory sweating (CS) is the most common adverse event and the main cause of dissatisfaction among patients undergoing a VATS sympathectomy for the treatment of primary hyperhidrosis. It has been described that obese individuals experience more sweating than thinner ones. The aim of this study is to identify the Body Mass Index (BMI) and the level of resection as predictive factors for CS and its relation to levels of patient satisfaction following the procedure. *Methods* From October 1998 to June 2003, 102 patients undergoing VATS sympathectomies (51 for palmar hyperhidrosis, PH, and 51 for axillary hyperhidrosis, AH) were prospectively surveyed. They were divided into three groups according to their BMI: Group I was composed of 19 patients with BMI < 20 (9 patients with PH and 10 with AH); Group II was composed of 52 patients with $20 \leq BMI < 25$ (25 with PH and 27 with AH); and Group III was composed of 31 patients with $BMI \geq 25$ (17 with PH and 14 with AH). Each procedure was simultaneously and bilaterally performed under general anesthesia using two 5.5 mm trocars and a 30° optic system. *Results* Patients treated for PH (resection of T2-T3) had more severe CS than those with AH (resection of T3-T4) ($p = 0.007$) and the greater the BMI, the greater the severity of the CS ($p < 0.001$). No statistically significant difference was found between the BMI bands in relation to the degree of satisfaction ($p = 0.644$), nor when we compared the degree of satisfaction to the degree of CS ($p = 0.316$). *Conclusions* The greater the BMI, the more severe the CS, but this did not correlate with the patients' level of satisfaction. Avoiding the resection of T2 sympathetic ganglia is also important in reducing the intensity of CS.

Key words body mass index · compensatory sweating · sympathectomy · quality of life · subjective rating scale

Introduction

Video-assisted thoracic surgery (VATS) is the optimal surgical technique for performing a thoracic sympathectomy (TS) in the treatment of primary hyperhidrosis since it is a safe, effective and minimally invasive method [1]. However, in addition to the complications of pneumothorax and hemothorax, which are totally reversible, the major adverse event which may result from

the operation in some cases is compensatory sweating (CS).

CS consists of an increase in the severity of sweating in locations that were previously normal. Because of its high frequency occurrence, it is the most feared adverse event following a VATS sympathectomy [1, 5, 7, 10, 12, 18]. When severe, CS is considered the main cause of patient dissatisfaction since it significantly affects the patient's quality of life [3]. Thus, it would be useful to identify some predictive factors so that particularly susceptible patients could take preventive measures and thereby improve their quality of life.

It has been observed that obese individuals present more severe sweating than the general population [11]. The reason why they do so is unclear in the literature. It is probable that obese individuals, who have a thick layer of fat in the subcutaneous tissue, have greater difficulty in losing heat through convection and irradiation, and so evaporation becomes the natural compensatory mechanism. Thus, sweating is likely the chief means of regulating an increase in body temperature. A simple means of measuring an individual's nutritional state is by calculating the Body Mass Index (BMI) [2, 6, 8, 9].

The objective of this study was to verify the relationship between an individual's nutritional state as represented by BMI, the severity and degree of CS, the level of resection, and the level of satisfaction following a VATS sympathectomy for the treatment of primary hyperhidrosis.

Material and methods

This was a prospective, non-randomized, and uncontrolled study. From October 1998 to June 2003, data were collected from 102 patients with palmar hyperhidrosis (PH) who underwent thermoablation of the T2 and T3 ganglia or the T3 and T4 ganglia for primary palmar or axillary hyperhidrosis (AH) using VATS sympathectomy, respectively. The patients all underwent similar treatment, following the same protocol. The treatment was in accordance with the hospital's ethical standards as set by the Ethics Committee for Analysis of Research Projects on Human Experimentation. The mean age was 27.6 ± 7.2 years, ranging from 15 to 45 years; 62 patients were female (60.8 %). The complaints causing the greatest social interference in the group were PH in 51 patients and AH in the other 51.

All patients underwent a bilateral VATS sympathectomy. The patients with preferential PH were submitted to thermoablation of the T2 and T3 ganglia and those with AH to that of the T3 and T4 ganglia. The surgical techniques employed included two 5 mm incisions. The first incision was made in the fourth or fifth submammary intercostal space in order to introduce the camera (30°), and the second was midaxillary, for the surgical instruments. Ablation using an electrical or harmonic scalpel was the chosen technique in all cases.

No mortality or conversion to open surgery occurred in our series. All of the patients showed uneventful postoperative progress and were discharged on the day after the surgery. Only two patients had temporary Horner's syndrome, with regression to normal in 30 days. As part of routine follow-up, clinical examinations were provided in the first, third, and sixth month, and at six month intervals thereafter. The patients were followed for periods from 1 to 38 months (an average of 12.8 months and a median of 10.2 months).

All of the patients underwent at least three evaluations for the purpose of this study: immediately prior to and after surgery and at the final clinical evaluation. At the first visit, patients were given a thorough clinical evaluation. After measuring their BMI and identifying the symptoms causing the greatest social interference, either palmar or axillary hyperhidrosis, they were treated. We considered the last evaluation from all data collected. To calculate each patient's BMI, the patient's weight (kg) was divided by the square of his or her height (m^2).

The patients were divided into three groups according to their BMI as it stood immediately before surgery: less than 20; between 20 and 25; and greater than 25. The patient distribution according to their BMI and hyperhidrosis site is presented in Table 1. No statistically significant difference was found between the hyperhidrosis location and the patients' BMI ($p = 0.690$).

Patients who did not notice any difference in the location or intensity of their sweating were considered to be unaffected by CS. Slight compensatory sweating was considered to exist when patients referred to minor modifications in the locations and intensity of sweating, such as a blot on a shirt, but without expressing significant concern as a result. Moderate compensatory sweating was considered to exist when patients referred to embarrassing or disabling situations caused by CS. Finally, severe compensatory sweating was considered to exist when patients referred to interference in their social and professional activities, such as successive changing of clothes, due to sweating of the same intensity but at other primary locations.

For the postoperative evaluation, patients filled out a subjective rating scale (multiple test) at every visit, without any intervention or advice from the interviewer, based on their own estimates. The following parameters were studied: recurrent hyperhidrosis and CS. If the latter was present, its severity was recorded as slight, moderate, or severe, according to the patient's subjective perception, as described above. Finally, the patient satisfaction with regard to the procedure's final results (including both the treatment and any complications) was subjectively evaluated by means of a multiple choice subjective rating scale (four options) in which the patients could place themselves on a satisfaction scale as follows: 1- deficient, 2- regular, 3- very good, 4- excellent.

At first, the result from the VATS sympathectomy was analyzed in relation to the success of the treatment for each hyperhidrosis location. Next, we analyzed the relationship of the BMI with the presence and degree of CS and also with the patients' level of satisfaction. The relationship between the degree of CS and patient satisfaction was also studied.

The statistical tests utilized were the chi-squared test and a multivariate analysis in which a discriminatory analysis technique was applied using the "stepwise" method for the selection of variables. Variables associated with $p < 0.05$ on univariate analysis were included in multivariate analysis. This was to verify whether the variables that were significant in the univariate analysis continued to be significant when in association. In both tests we considered a significance level (p value) of 0.05.

Table 1 Patient distribution according to BMI and hyperhidrosis location

BMI (kg/m^2)	Hyperhidrosis location		Total sample n (%)
	Palmar hyperhidrosis n (%)	Axillary hyperhidrosis n (%)	
< 20	9 (17.6)	10 (19.6)	19 (18.6)
between 20 and 25	25 (49.0)	27 (52.9)	52 (51.0)
> 25	17 (33.3)	14 (27.5)	31 (30.4)
Total	51 (100.0)	51 (100.0)	102 (100.0)

Chi-squared test: $p = 0.690$

Results

We observed the success results (anhidrosis) in 94 patients (92.1 %). In the palmar group, this occurred in 90.4 % of cases and in 94.3 % of cases in the axillary group. The treatment was ineffective (on only one side) in five patients with PH and three with AH. CS was observed in 97 patients (95.1 %), and their characteristics are shown in Table 2. A statistically significant difference was found between the hyperhidrosis locations in relation to the degree of CS ($p = 0.007$).

It should be highlighted that CS in patients treated for PH (resection of T2-T3) was more severe than for those treated for AH (resection of T3-T4). Among patients with PH, the main area of sweating reported was the torso (22 patients; 44.9 %), followed by the back region (20 patients; 40.8 %). On the other hand, among patients with AH, CS was seen on the back in 22 patients (45.8 %), followed by the torso in 21 patients (43.7 %). An analysis of the BMI in relation to the degree of CS is presented in Fig. 1. A statistically significant difference was found between the BMI bands in relation to the degree of CS ($p < 0.001$).

We observed that the greater the BMI, the greater the severity of CS. When we analyzed the degree of CS in relation to PH and AH, we observed the same results ($P < 0.001$ and $p = 0.02$, respectively). The analysis of the BMI in relation to the degree of satisfaction is presented in Table 3. No statistically significant difference was found between the BMI bands in relation to the degree of satisfaction ($p = 0.644$). When we stratified separately for the palmar and axillary hyperhidrosis groups, we observed the same proportions. No statistically significant difference was found between the degree of satisfaction in relation to the degree of CS ($p = 0.316$).

A multivariate, discriminant analysis technique was applied, utilizing the "stepwise" method for the selection of variables (BMI, satisfaction degree and level of the resection), in order to verify whether the variables that were significant in the univariate analysis continued to be significant when in association. Statistically significant associations were found between the degree of CS and the BMI ($p < 0.001$) and the level of the resection (hyperhidrosis location) ($p = 0.007$). No statistically significant association was found between the degree of CS and the patients' degree of satisfaction ($p = 0.316$).

Table 2 Compensatory sweating characteristics in relation to treated location

Degree of compensatory sweating	Hyperhidrosis location		
	Palmar hyperhidrosis n (%)	Axillary hyperhidrosis n (%)	Total sample n (%)
Slight	12 (24.5)	26 (54.2)	38 (39.2)
Moderate	20 (40.8)	15 (31.3)	35 (36.1)
Severe	17 (34.7)	7 (14.6)	24 (24.7)
Total	49 (100.0)	48 (100.0)	97 (100.0)

Chi-squared test: p = 0.007*

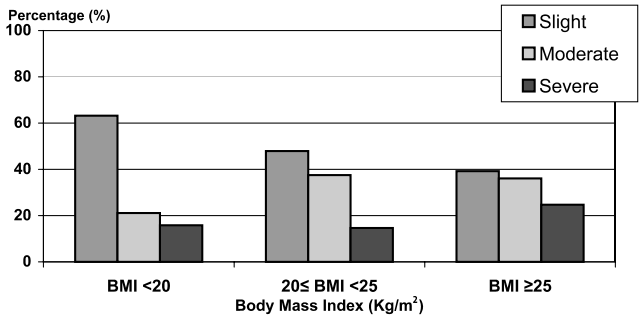

Fig. 1 BMI in relation to the degree of compensatory sweating

Discussion

CS is the most frequent complication following a VATS sympathectomy. In this study, 95.1 % of the patients presented this adverse event, being at the most severe level in 24.7 % of the cases. CS was seen as one of the most significant signs of unsuccessful surgery. We believe that this high incidence is related to the fact that Brazil has a tropical climate and the weather is often hot, naturally resulting in profuse sweating. This is a normal physical response to the ambient temperature, in spite of the fact that postoperative CS may result in environments with high or low temperatures. If we consider only severe levels, our results will probably be similar to other studies. Many modified endoscopic thoracic sympathectomy methods have been designed to avoid the occurrence of CS, but none of them have thus far achieved the desired result [4].

The methods of quantifying reflex sweating are usually subjective [3, 12]. We utilized a subjective rating scale form that proved useful and seemed to be a good

Table 3 Degree of satisfaction related to final results in relation to BMI

Degree of satisfaction	BMI (kg/m²)			
	< 20 n (%)	between 20 and 25 n (%)	> 25 n (%)	Total sample n (%)
Deficient	8 (42.1)	19 (39.6)	8 (26.7)	35 (36.1)
Regular	7 (36.8)	16 (33.3)	10 (33.3)	33 (34.0)
Very good	3 (15.8)	9 (18.8)	6 (20.0)	18 (18.6)
Excellent	1 (5.3)	4 (8.3)	6 (20.0)	11 (11.3)
Total	19 (100.0)	48 (100.0)	30 (100.0)	97 (100.0)

Chi-squared test: p = 0.644

means to quantify the evolution of reflex sweating intensity.

From our observations, the main locations for CS are the torso and back. It has been suggested that CS has a correlation with the extent of the resection and also the level of the resection [14, 15]. In this series, two ganglia were resected in each of the two groups (palmar and axillary hyperhidrosis). Thus, the extent of the resection was the same, although the level was lower for the AH (T3 and T4) than for the PH (T2 and T3). This demonstrates that the level of the resection may be the most important point. Also supporting this theory, Lin & Telaranta in 2001, reported that CS was less prevalent in patients submitted to T3 and T4 sympathetic surgery than patients submitted to T2 surgery. They believe that the higher the interruption or resection of the sympathetic chain, the more afferent fibers responsible for the inhibition of sweating would be harmed, therefore, causing a considerable increase in the quantity and intensity of CS [13].

A variety of factors such as age, sex, family history, the presence of plantar hyperhidrosis and the performance of extensive resections, as mentioned above, have already been studied as predictive factors for CS [12]. From our observations of increased incidence of sweating among obese individuals, we decided to study the relationship between the patient's nutritional state and the degree of CS after a VATS sympathectomy. No studies of this relationship were found in the literature for comparison.

The patient's nutritional state can be estimated by the anthropometric measurements including body mass index, skinfold and arm circumferences. The BMI is useful, easy and inexpensive in the clinical setting but has limited accuracy and cannot be used to establish the proportion of fat free mass (FFM) and fat mass, as measured by bioelectrical impedance analysis (BIA) and dual-energy X-ray absorptiometry (DXA), but it has a good correlation with fat mass and FFM associated [16, 17].

The body mass index (BMI) is an estimate of the body fat based on the ratio of a patient's height to his or her weight. It is a mathematical formula using either imperial or metric measurements. This applies to both adult men and women and is more highly correlated with body fat than any other indicator of height and weight [9].

However, in some cases being overweight using the BMI index may not necessarily be due to an overabundance of body fat. Weight can also come from muscle tissue, such as in the case of weight lifters or other athletes that engage in muscle-building exercise. They may be very lean and muscular and may weigh more than others of similar build because of their larger muscle mass. We had no patients with characteristics like these in our cohort. The BMI is a good tool for indicating weight status mainly in adults [2, 6, 8, 9].

For adults over 20 years of age, the BMI classification is defined as follows: malnourished ($\leq 18.49\,kg/m^2$), low weight ($18.50–19.99\,kg/m^2$), normal ($20.00–24.99\,kg/m^2$), overweight ($25.00–30.00\,kg/m^2$) and obese ($> 30.00\,kg/m^2$).The BMI ranges are also based on the effect body weight has on disease and death [2, 6, 8, 9]. As the BMI increases, the risk for some diseases increases. The BMI is only one of many factors used to predict these risks factors for disease and cannot be used to definitively diagnose a particular disease. Some common conditions related to overweight and obesity include premature death, cardiovascular disease, high blood pressure, osteoarthritis, some cancers, diabetes and an increase in the risk of CS in patients treated for primary hyperhidrosis as we observed in our data.

When we studied the relationship between the nutritional state and the degree of CS, we observed that the greater the BMI, the greater the degree of CS. However, we did not observe any relationship between the BMI and the patient's degree of satisfaction (Table 3). This was perhaps because those patients with a higher BMI already presented greater sweating in the torso and back before the surgery. We also believe that the patient's degree of satisfaction is not only related to the result (anhidrosis), but also to the patient's expectations with regard to complications. Due to the fact that patients currently receive much more information on the risks and benefits of any surgical procedure, they are probably more aware of all of the possible adverse events and are therefore better able to cope with them than in the past.

Conclusion

Our findings may be summarized as follows: the greater the BMI, the more severe the CS. Nonetheless, this does not affect the level of patient satisfaction following surgery. In addition, avoiding the resection of T2 sympathetic ganglia is also important in reducing the intensity of CS. However, other clinical studies should be performed to correlate different anthropometric methods with compensatory sweating.

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