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Thoracoscopic sympathectomy for palmar and axillary hyperhidrosis: four-year outcome and quality of life after bilateral 5-mm dual port approach

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Abstract
Background During recent years, thoracoscopic sympathectomy has been the standard treatment for hyperhidrosis. Different surgical techniques have been described without proving their advantages compared with other procedures. This study was designed to evaluate our modification of thoracoscopic sympathectomy and to compare the effectiveness between axillary and palmar hyperhidrosis.
Methods Ninety patients with axillary or palmar hyperhidrosis who underwent bilateral thoracoscopic sympathectomy with single-lumen ventilation with a dual 5-mm port approach were followed up for a median of 3.9 (range, 1–6) years. The clinical course and data during the hospitalization and consultation in our outpatient clinic were reviewed. The following parameters were evaluated: clinical improvement, satisfaction, changes in quality of life, and compensatory sweating and gustatory sweating.
Results The perioperative mortality was 0, and the morbidity was 6.5%. In 81% clinical improvement of sweating was noticed; 55% did not sweat at all. A total of 88% of patients were satisfied with the result of the operation. The rates of compensatory sweating and gustatory sweating were 93.5% and 49.4%, respectively. The result of sympathectomy in patients with palmar hyperhidrosis were significantly better concerning rate of satisfaction ($p = 0.006$) and improvement of symptoms ($p = 0.027$) compared with patients with axillary symptoms. Additionally it was found that the compensatory sweating had significantly impacted the satisfaction rating of the operation.
Conclusion Currently different effective surgical approaches for the treatment of hyperhidrosis with improvement rates of more than 80% are available. The quality of the intervention has to be evaluated by changes in quality of life and intensity of compensatory sweating. Thoracoscopic sympathectomy as performed in our institution offers results and complications comparable to previously published trials; however, because of single-lumen ventilation the management is much easier. Therefore, this technique offers an interesting option for the treatment of patients with palmar and axillary hyperhidrosis.

Keywords Thoracoscopic sympathectomy · Hyperhidrosis · Outcome · Compensatory sweating

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Primary hyperhidrosis is a condition characterized by oversecretion of the eccrine sweat glands of unknown etiology. Sweating is emotionally, socially, and professionally distressing and may hinder daily activities. It affects 0.6–1% of the population [1, 2]. Symptoms of hyperhidrosis usually appear in childhood or puberty [3]. Hyperhidrosis is characteristically disproportionate to sweating for thermoregulation and dissipation of body heat [1, 4]. It is more common in women [5, 6]. A family history was discussed as evidential by Baumgartner and Toh [7].

Historically hyperhidrosis has been treated surgically by subcutaneous curettage or excision of the skin containing the eccrine glands. Sympathectomy via thoracotomy has been published but has not had widespread use due to its complications. Originally sympathectomy was performed

in patients with hypertonia, angina pectoris, or vegetative dystonia [8]. In an experimental setting, the first thoracoscopic sympathectomy was performed in 1942 by Hughes and later advanced by Kux in 1954 [2, 7, 9]. In 1990 the first video-assisted thoracoscopic surgery was performed [1]. In recent years thoracoscopic sympathectomy has become the standard treatment for severe hyperhidrosis. It is a simple, safe, and effective procedure with a short hospital stay and good cosmesis [10–12].

The most frequent indications for sympathectomy are palmar and axillary hyperhidrosis. Different surgical techniques have been described without proving their advantages compared with other procedures.

This study was designed to evaluate our modification of the sympathectomy. Besides rates of improvement and satisfaction, we focused on compensatory and gustatory sweating.

Materials and methods

Study design and patients

Between 2001 and 2006, 90 patients with palmar or axillary hyperhidrosis underwent thoracoscopic sympathectomy at the Department of Surgery, University Medical Center Hamburg-Eppendorf. Diagnosis was based on clinical feature. Written, informed consent was obtained from all patients. All data, including sex, age, medication, and complications, were obtained from clinical records. Clinical follow-up data were obtained by reviewing hospital records and direct communication with the patients or attending physicians. All patients answered a questionnaire concerning changes in sweating and quality of life (scale: strongly improved, improved, unchanged, worsened) as well as compensatory and gustatory sweating (very strong, strong, moderate, mild, no gustatory/compensatory sweating) and overall satisfaction with the results of the operation.

Operation

All interventions were performed as simultaneous bilateral sympathectomy. Single-lumen endotracheal intubation was performed; the patient was placed in normal back position. On both sides, a 5-mm port and scope were inserted below the lower margin of the pectorals muscle; a second port was inserted in the anterior axillary line at the forth or fifth intercostal space. Collapse of the lung was achieved by inflation of room air. The sympathetic nerve was identified in short apnea, and a partial pleurectomy (from lower margin of the second rib to upper margin of the fifth rib) was performed. The side branches were transected (cauterized), followed by transsection of the sympathetic nerve at the upper margin of the fifth rib. The nerve was dissected up to the second rib and transected at the lower margin of the second rib. The pleura were opened along the second rib to detect possible short nerves. To inflate the lung optimally, suction with 20 mmHg and simultaneous ventilation of the lung under thoracoscopic vision was performed and the ports were removed (Fig. 1). Chest X-ray was taken in recovery.

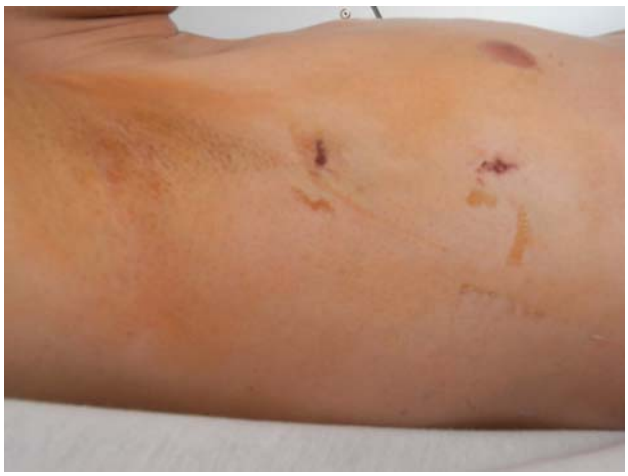

Fig. 1 Postoperative day 1 after thoracoscopic sympathectomy

Statistical analysis

SPSS® for Windows® (Version 11.5.1; SPSS Inc., Chicago, IL) was used for statistical analysis. For all variables, cross-tables were generated, followed by calculation of p value by using χ^2 test/Fisher's exact test. The values of the different groups were compared by using Student's t test. Significance statements refer to p values of two-tailed tests that were <0.05. For analyzing the correlation, Pearson correlation (r) was calculated.

Results

Characteristics of the patients

Seventy-seven of 90 patients with hyperhidrosis who were treated in our institution were eligible for follow-up. Median overall follow-up period was 3.9 (range, 1–6) years; no patient died. Patients' characteristics are listed in Table 1. The median age of the included patients (at time of surgery) was 35 (range, 15–51) years; 23 patients (29.9%) were men, and 54 patients (70.1%) women.

The median time between onset of hyperhidrosis and time of surgery was 11 (range, 1–45) years. Before the operation, 30 (39%) patients used deodorants, 16 (20.8%) underwent Botox injection, and 1 (1.3%) patient was treated

Table 1 Clinicopathological characteristics

Male	23	(29.9)
Female	54	(70.1)
Age (median/range)	35.2	(15–51)
Duration of symptoms (yr)	11.4	(1–45)
Axillary hyperhidrosis	29	(37.7)
Palmar hyperhidrosis	48	(62.3)
Overall	77	

Data are numbers with percentages or ranges in parentheses

Table 2 Disturbance by hyperhidrosis

	Disturbance by hyperhidrosis			
	Strong	Moderate	Mild	No
Working ability	85.7%	10.4%	1.3%	2.6%
	66	8	1	2
Daily activity	79.2%	20.8%	0%	0%
	61	16	0	0
Hobbies	48.1%	28.6%	13.0%	10.4%
	37	22	10	8

by excisions of the eccrine sweat glands. The mean duration of the hospital stay was 1.8 (±1.3) days postoperatively; the mean operation time was 63.2 (±23.3) minutes.

Forty-eight patients suffered from primary palmar hyperhidrosis and 29 patients from axillary hyperhidrosis. In the palmar group, 34 patients had additional minor axillary sweating, whereas only 8 patients of the axillary hyperhidrosis group had additional minor palmar sweating. Thirty-two patients had additional sweating at other locations (22 feet, 7 face, 3 back). The intensity of the preoperative palmar sweating was classified as severe in 48 (62.3%), moderate in 4 (5.2%), and mild in 4 (5.2%); 21 (27.3%) patients had no palmar sweating. The intensity of the preoperative axillary sweating was classified as severe in 43 (55.8%), moderate in 13 (16.9%), and mild in 7 (9.1%); 14 (18.2%) patients had no axillary sweating. The patients felt mostly disturbed in daily life activity and working ability followed by interference of their hobbies (Table 2). No significant differences were found comparing palmar and axillary hyperhidrosis.

Effects on outcome and quality of life

After sympathectomy, 62 (80.6%) patients had clinically improved, and 32 (41.6%) were completely free of sweating. Eight (10.4%) patients were unchanged and seven (9.1%) had worsened.

According to these findings, the quality of life had strongly improved in 47 (61.0%) patients, improved in 18 (23.4%) patients, 5 (6.5%) patients were unchanged, and 7 (9.1%) had worsened. The rate of improvement of symptoms was significantly better in patients with palmar hyperhidrosis (87.5% vs. 69%; $p = 0.027$). The improvement of the quality of life was better in palmar hyperhidrosis, but this was of borderline significance ($p = 0.063$) only (Table 3).

Table 3 Impact of clinicopathological data on outcome in patients with hyperhidrosis

	Palmar (%)	Axillary (%)	p value
Improvement of quality of life	91	72	0.063
Improvement of sweating	88	69	0.027
Excessive dry hand	35	65	0.018
Satisfaction	85	62	0.006

Table 4 Influencing factors on overall satisfaction

Influencing factor	p value	r^a
Compensatory sweating	<0.001	0.436
Gustatory sweating	0.029	0.249
Improvement of quality of life	<0.001	0.838
Changes of sweating	<0.001	0.719

[a] Pearson correlation

Forty-six (59.7 %) patients were completely satisfied with the overall results of the operation, 13 (16.9 %) were satisfied, and 9 (11.7%) were moderately satisfied. Nine patients (11.7 %) were unsatisfied.

The rate of overall satisfaction was significantly higher after sympathectomy in patients with palmar hyperhidrosis ($p = 0.006$; Table 3). Rating the mean quality of life preoperatively, no significant differences between patients with palmar and axillary hyperhidrosis were found (33.96 ± 3.5 vs. 35.52 ± 4.17). According to higher rates of improvement, postoperatively the quality of life was significantly better in patients with palmar sweating (83.54 ± 3.71 vs. 66.9 ± 5.37; $p = 0.01$).

When analyzing the influencing factors of overall satisfaction, a highly significant correlation was found for improvement of quality of life ($p < 0.001$; $r = 0.838$), improvement of sweating ($p < 0.001$; $r = 0.719$), compensatory sweating ($p < 0.001$; $r = 0.436$), and gustatory sweating ($p = 0.029$; $r = 0.249$; Table 4).

Side effects of operation

The mortality was 0; the overall morbidity rate was 6.5%. In four (5.2%) patients, a pneumothorax was detected during routine postoperative chest X-ray; no patient required an intervention or drainage. One patient suffered from persistent pain for 6 months after sympathectomy.

Table 5 Grade of postoperative interference

Interference (postoperative)	Very strong	Strong	Moderate	Mild	No
Compensatory sweating (%)	29.9	26	28.6	9.1	6.5
Gustatory sweating (%)	1.3	10.4	16.9	20.8	50.6

Table 6 Localization of compensatory sweating

Compensatory sweating		
Localization	*n*	Percent
Back	44	57.1
Chest	34	44.2
Legs	21	27.3
Bottom	13	16.9
Face	4	5.2

Thirty-six (46.8%) patients noticed excessively dry hands and had to use hand cream daily. The rate of dry hands was significantly higher for patients with axillary hyperhidrosis (65.5%; $p = 0.01$) compared with patients with palmar symptoms (35.4%).

Gustatory sweating was noticed in 38 (49.4%) patients. It was rated to very strong in 1.3%, strong in 10.4%, moderate in 16.9%, and mild in 20.8% of patients. Seventy-two of 77 (93.5%) patients suffered from compensatory sweating: rated as very strong in 29.9%, strong in 26%, moderate in 28.6%, and mild in 9.1% of patients (Table 5). It was mostly located at the back, chest, and legs (Table 6).

Discussion

For severe hyperhidrosis, thoracoscopic sympathectomy is the "gold standard" of treatment [9, 13–18]. The rate of improvement is usually > 80%, but the rate of satisfaction and compensatory sweating varies. Different surgical techniques have been published during the last decades. Open sympathectomy is rarely performed currently because of higher morbidity, longer operation time, and hospital stay [9, 15, 19–21]. Besides thoracoscopic sympathectomy, clipping of the sympathetic nerve has been described as an alternative procedure with comparable results [22, 23]. Clips have the advantage that they can be removed if the compensatory sweating is more disturbing than primary hyperhidrosis. The extent of sympathectomy varies from resection of a single ganglion, most commonly T2 or T3, to complete resection, from T2 to T5 [24]. Additionally, selective sympathectomy was described without compensatory sweating but was found to be ineffective [25, 26].

Our approach offers several advantages. The operation time is short and the management is easier, because the patient is operated on in normal back position and no double-lumen tube is necessary. Additionally the risk of atelectasis is reduced. Only two 5-mm trocars are necessary on each side, therefore, optimal cosmetic results can be achieved.

Nonsurgical treatment

Topical therapy with antiperspirants that contain low-dose metal salt is only effective in mild hyperhidrosis by blocking the opening of the sweat gland ducts. This therapy often is limited by skin irritations. Other treatments include acupuncture, electrolytic therapy, and iontophoresis; however, these are mostly unsuccessful.

In conservative treatment, the injection of botulinum toxin (Botox) is used, which blocks the release of neuronal acetylcholine from the presynaptic junction of the both neuromuscular and cholinergic autonomic neurons. It provides a reduction of the sweat secretion. The mean duration of the improvement is 7–11 months with a cost of $150–$300. The best indication is isolated axillary hyperhidrosis. Injection of Botox caused paresis of the intrinsic muscles of the hand in >60% of patients [27]. Medical therapies often are unsuccessful and have complications [9, 28].

CT-guided lyses of the sympathetic nerve are associated with a rate of Horner's syndrome in 14% of patients and recurrence of hyperhidrosis after 4 months in 18%. The rate of overall satisfaction was 70–80%, which is lower compared with thoracoscopic sympathectomy [29, 30]. Because of the associated complications and short relief of symptoms and post-inflammatory adhesion that can complicate probable later thoracoscopic intervention, this technique cannot be advocated.

Pathoanatomical problems

The precise sympathetic innervation of the axilla is unknown, but that of the remainder of the upper limb is well defined [31]. The sympathetic nerve supply to the upper limb arises from the second to sixth thoracic segments of the spinal cord and enters the corresponding sympathetic ganglia. The sympathetic fibers are distributed to the limb via the somatic nerves arising from spinal segment C5-Th1 and ascend to join the brachial plexus [13].

The spinal cord influence over the remaining sympathetic nervous system may be short circuited by the loose and reorganization of the axons after sympathectomy, hence, increased sympathetic tone may occur in the remaining sweating body areas [32].

The difficulty of the anatomy is underlined by findings of Horner's syndrome in only 17.3% (instead of expected

100%) of patients after resection of the first ganglion, which is inexplicable by known anatomical facts [13].

It was shown that the intraoperative measurement of skin temperature elevation is an indicator of successful sympathetic outflow blockage to the palms [33]. It was shown that endosomatic electrodermal activity may return after sympathectomy, but no correlation with recurrence of excessive sweating was detected [9]. Sympathetic nerve regeneration has been proposed and one case of complete regeneration of the sympathetic chain has been demonstrated histologically [20, 34].

The main problem of this intervention is compensatory sweating [10]. Mostly this side effect was found to be moderate or mild and was tolerated by the patients. The level of severe compensatory sweating that was found in 2–8% seems to be more important than the overall rate of compensatory sweating [10, 26, 35, 36]. No definition of severe compensatory sweating exists; therefore, the evaluation of the quality of life is an important factor [10].

Side effects

Complications occur in 3–10% of patients; most common are Horner syndrome, recurrence, hemorrhage, and pneumothorax [17, 24, 37–39]. A small insignificant pneumothorax can be expected in 75% of patients, which gets absorbed spontaneously usually within 24 hours [1, 40]. The rate of chest drainage was found to be 0–8% [1, 17, 25, 27, 41, 42].

No patient in our trial needed chest drainage or suffered from Horner's syndrome. Therefore, our technique is at least equal to the previously published methods in terms of morbidity. Excessively dry hands were found previously in 51% of patients, which is comparable to our findings [27]. The mean operation times differ from 39–124 minutes in previous trials [43–45]. The rate of recurrence was 0–14% [45, 46]; during our follow-up no recurrence was noticed.

Analysis of compensatory sweating

Previously the rate of compensatory sweating was up to 100% [8, 17, 42, 47–56], which is in accordance to our findings. Some authors report a gradual decrease in the grade of intensity of compensatory sweating during a longer follow-up period [17, 57–59]. Compensatory sweating is mostly located at the trunk or lower limbs as in our trial [10]. The rate of compensatory sweating is said to be the marker of quality of sympathectomy [24].

In a trail comparing T3 vs. T3/4 sympathectomy, the T4 group had a significantly higher rate of compensatory sweating (32% vs. 9%), but the patients in the T4 group displayed a significantly higher rate of (complete) satisfaction (94% vs. 66%) [43]. Therefore, it had to be concluded that the rate of compensatory sweating was not the marker for quality of sympathectomy.

The rate of compensatory sweating was found to be 2–5% after resection of T2-4, 0% after resection of T2, and 3.6% after T3/T2-3 resection [10, 35, 43, 60, 61]. Schmidt and colleagues found a significantly lower rate of compensatory sweating after resection from T3-T5 compared with resection from T2-T4 [24]. Other authors stated that axillary hyperhidrosis requires resection as far as T4 [35, 62, 63]. Additional resection from T4-T5 was said to improve the results for armpit hyperhidrosis [36]. A limited resection of T4/5 as described by Hsu and colleagues offers good result in 86%, with compensatory sweating in only 29%. Some authors suggest saving the sympathetic trunk and selectively blocking the communicating branches and postganglionic fibers (Wittmoser procedure) [1, 25].

Some authors suggest the resection of the second and third ganglion to achieve anhidrosis of the hands. The resection of the fourth ganglion was suspicious to be the reason for compensatory sweating [13, 64, 65]. Kopelman et al. found a rate a compensatory sweating of only 5.8% after preservation of the fourth ganglion [47]. Therefore, some authors advocate a limited resection [49, 66, 67]. There is no evidence concerning the extent of dissection or resection so far [24, 68, 69]. Interestingly >90% of patients with compensatory sweating were satisfied with the results of the operation [27, 39]. Other authors pointed out that the rate of compensatory sweating is not related to the extent of sympathectomy if it is not beyond the forth ganglion. The reason for the compensatory sweating might be ineffective sympathectomy or prone to surgical failure [18, 36, 49, 70].

Gustatory sweating was observed in 1–30% of patients [3, 26, 71–73]. It might be caused by an aberrant anastomosis between sympathetic trunk and the vagal nerve [39, 49].

As found in our study populations, the rate of satisfaction with the overall results of the operation was as much as 90% [10, 27, 39]. In a previous trial, improvement of the quality of life was 90–98% [10, 27].

By analyzing the influencing factor of overall satisfaction, we could confirm the impact of the intensity of compensatory sweating next to the improvement of symptoms, whereas gustatory sweating has no statistically proven impact. In a previous trial the rate of improvement and satisfaction were lower in the axillary group compared with the palmar group (83% vs. 100% and 67% vs. 93%, respectively), which is in accordance with our findings [10, 26, 62].

Conclusions

Different effective surgical approaches for the treatment of hyperhidrosis with improvement rates >80% are available.

The quality of the intervention has to be evaluated by changes in quality of life and intensity of compensatory sweating. Thoracoscopic sympathectomy as performed in our institution offers comparable results and complications as previously published trials, but due to single-lumen ventilation the intraoperative management is much easier. Therefore, this technique offers an interesting option for the treatment of patients with palmar and axillary hyperhidrosis.

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