Evaluation of the effectiveness of thoracic sympathectomy in the treatment of primary hyperhidrosis of hands and armpits using the measurement of skin resistance

Piotr Misiak, Sławomir Jabłoński, Beata Rzepkowska-Misiak, Łukasz Piskorz, Marian Brocki, Szymon Wcisło, Jacek Smigielski, Jacek Kordiak

Department of Chest Surgery, General and Oncological Surgery, University Hospital WAM and CSW Medical University of Lodz, Poland

Videosurgery Miniinv 2012; 7 (3): 147-155
DOI: 10.5114/wiitm.2011.26843

Abstract

Introduction: *Hyperhidrosis is excessive sweating beyond the needs of thermoregulation. It is disease which mostly affects young people, often carrying a considerable amount of socio-economic implications. Thoracic sympathectomy is now considered to be the "gold standard" in the treatment of idiopathic hyperhidrosis of hands and armpits.*
Aim: *Assessment of early effectiveness of thoracic sympathectomy using skin resistance measurements performed before surgery and in the postoperative period.*
Material and methods: *A group of 20 patients with idiopathic excessive sweating of hands and the armpit was enrolled in the study. Patients underwent two-stage thoracic sympathectomy with resection of Th2-Th4 ganglions. The skin resistance measurements were made at six previously designated points on the day of surgery and the first day after the operation.*
Results: *In all operated patients we obtained complete remission of symptoms on the first day after the surgery. Inhibition of sweating was confirmed using the standard starch iodine (Minor) test. At all measurement points we obtained a statistically significant increase of skin resistance, assuming $p < 0.05$. To check whether there is a statistically significant difference in the results before and after surgery we used sequence pairs Wilcoxon test.*
Conclusions: *Thoracic sympathectomy is an effective curative treatment for primary hyperhidrosis of hands and armpits. Statistically significant increase of skin resistance in all cases is a good method of assessing the effectiveness of the above surgery in the early postoperative period.*

Key words: *primary hyperhidrosis, thoracoscopy, sympathectomy, skin resistance.*

Introduction

The rapid development of video-optical techniques in the early 1990s has enabled the introduction of surgical procedures whose practice was limited due to difficult operating access, creating a risk of complications exceeding potential benefits of the surgery. In this group a special position is occupied by operations on the autonomic nervous system, which is situated in both pleural cavities. The operating accesses to the sympathetic trunk which were used in the past (both transpleural and extrapleural) were very traumatic and nowadays should be used only in severe conditions absolutely requiring a wide operating field. Thoracic sympathectomy is a well-known and effective surgical procedure which is commonly applied in treatment of vasomotor diseases (hyper-

Address for correspondence:
Piotr Misiak MD, PhD, 35 Długa, Chechło I, 95-082 Dobroń, Poland, phone: +48 510 115 108, e-mail: pitmis@interia.pl

hidrosis, Reynaud's disease, Bürger syndrome) within the upper limbs [1]. For the very first time, for facial hyperhidrosis treatment, it was performed in 1920 by Kotzareff [2]. However, Kux, who from 1954 conducted over 1400 thoracoscopic sympathectomies and vagotomies, is well known as the father of thoracoscopic operations [3, 4]. The development of minimally invasive techniques, through the improvement and miniaturization of medical instruments, helped to reduce the risk of the procedure and shorten hospitalization. Thoracic sympathectomy is a procedure which, in our clinic, consists of resection of the sympathetic trunk from Th2 to Th4.

Hyperhidrosis is a disease connected with excessive sweat secretion beyond the needs of thermoregulation. It is a condition associated with increased activity of eccrine sweat glands that are functionally innervated by cholinergic sympathetic fibres of the autonomic nervous system.

It is presumed that primary hyperhidrosis may concern about 3% of the world population. Treatment of the symptoms of excessive sweating costs over 0.5 billion dollars yearly in the USA alone [5-7].

Hyperhidrosis is not a life-threatening disease, but it may have serious social and economic implications.

Aim

The aim of this study was to assess early effectiveness of thoracic sympathectomy using skin resistance measurements performed before surgery and in the postoperative period at six designated points.

Material and methods

In 2007-2009, we performed 40 unilateral thoracic sympathectomies (20 patients; 16 females, 4 males), age distribution 15-38 years, median age 22 years (Table I). The majority, 17 patients, had applied at least two therapeutic methods before the operation (7 of them had received subcutaneous Botulinum toxin injections).

Table I. Patient characteristics

Study group	20
Age (range) [years]	22 (15-38)
Sex: male: female	1 : 4 (4 : 16)
Height: median (range) [cm]	170 (160-184)
Weight: median (range) [kg]	58 (45-88)
BMI: median (range) [kg/m^2]	19.64 (15.94-26.67)

All patients were referred to the clinic because of idiopathic excessive sweating in the palms and armpits. All patients were operated on using two working ports.

We introduced the first port (for videothoracoscopy) in the 4th intercostal space, in the mid-axillary line, and the second (for the working tool) in the 3rd intercostal space in the anterior axillary line. All patients were qualified for resection of Th2-Th4 ganglions combined with resection of connecting branches.

Each time the parietal pleura was delaminated at the distance of 3 cm in a line parallel to the sympathetic trunk in search of additional Kuntz fibres, which in the absence of resection are most often responsible for the failure of the operation (early recurrence of sweating, or residual sweating of the hands or armpits). We conducted the operation using a double lumen endotracheal tube. We did not insufflate additional carbon dioxide to the pleural cavity to increase lung compressions. We closed the chest under the direct control of videothoracoscopy and at the maximum positive airway pressure of 40 cm H_2O. We performed the skin resistance measurement on the day of the operation and the first day after. For the measurements we used a universal multimeter, Metex Me-31. This is a classic multimeter with the additional possibility of continuous monitoring and recording changes in resistance.

The multimeter was connected to a personal computer containing the special archiving program ScopeView ver. 1.08. The meter was equipped with 2 gold-plated electrodes spaced at a standardized distance of 1 cm. We observed changes in skin resistance for 10 s at each designated point. For the statistical analysis we used the average result of 10-s measurements.

The basic assumption of the method of measurement is that more moist skin conducts electrical impulses better, so its resistance will be lower compared to the resistance of dry skin (after surgery). In addition we proved the effectiveness of the surgery using the standard Minor test.

Results

The study group consisted of 20 patients (16 females and 4 males). Sixty percent were students and

therefore particularly vulnerable to stress associated with symptoms of excessive sweating.

Ten patients (50%) were admitted to the clinic due to excessive sweating of the hand and armpits, 10 (50%) due to excessive sweating of the hands. In all patients we performed the operation in two stages. The term of the second operation was chosen by patients according to their own preferences. The duration of the surgical procedure ranged from about 32 min to 53 min; median was 40 min (Table II). During the operation there were no serious complications such as bleeding or damage to lung tissue. Seven procedures had to be completed through pleural drainage due to difficulties in expansion of the lung under control of videothoracoscopy, which contributed to the prolongation of hospitalization (in 2 cases up to 5 days).

In all patients we performed the skin resistance measurements before surgery at six designated points:

1) central part of the axilla,
2) 2 cm above the centre of the armpit,
3) 2 cm below the centre of the armpit,
4) central part of the hand on the inside,
5) distal phalanx of the third finger on the palm,
6) thumb on the palmar side.

Table II. Operative details

Mean operating time (range) [min]	40 (32-53)
Mean period between operations [days]	37
Mean period of hospitalization [days]	3.2
Intraoperative complications	
Bleeding	0
Lung injury	0
Pneumothorax (with pleural cavity drainage)/ no. of operations	7/40

The results of measurements for each limb before surgery are shown in Figure 1 for the right limb, Figure 2 for the left limb. We made re-measurements on the first day after surgery. The results of re-measurements are shown in Figure 3 for the right limb, Figure 4 for the left limb, plus summary Table III.

At all measurement points we obtained a statistically significant increase of skin resistance, assuming

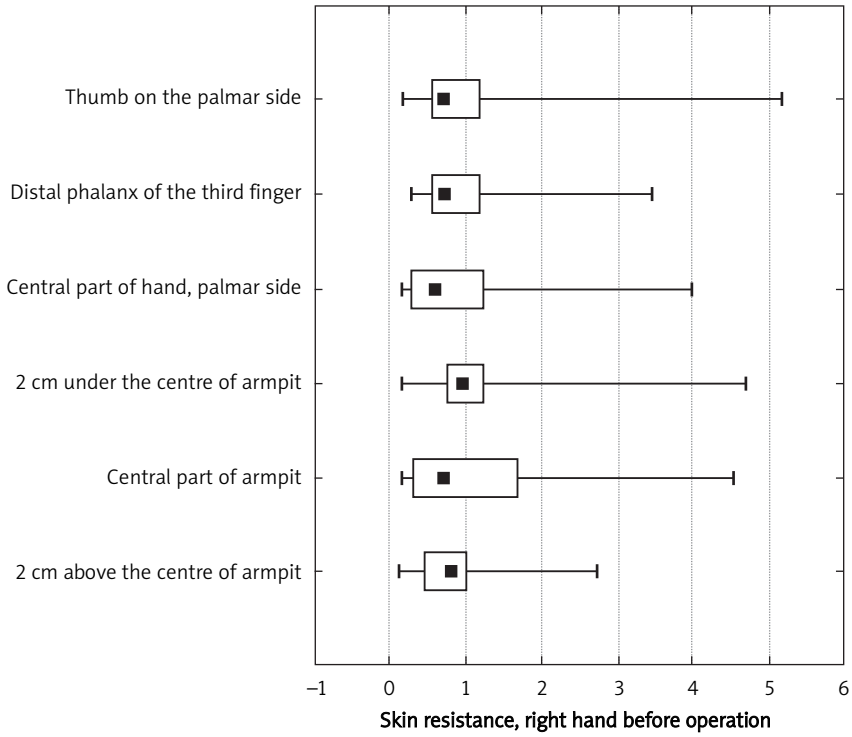

Figure 1. Skin resistance measurement on right hand before operation

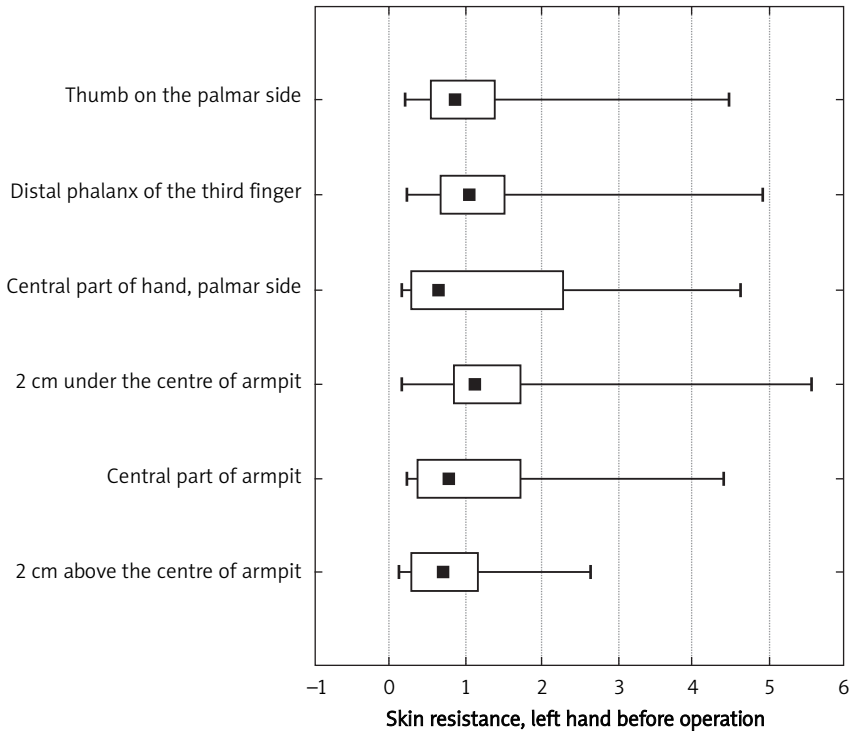

Figure 2. Skin resistance measurement on left hand before operation

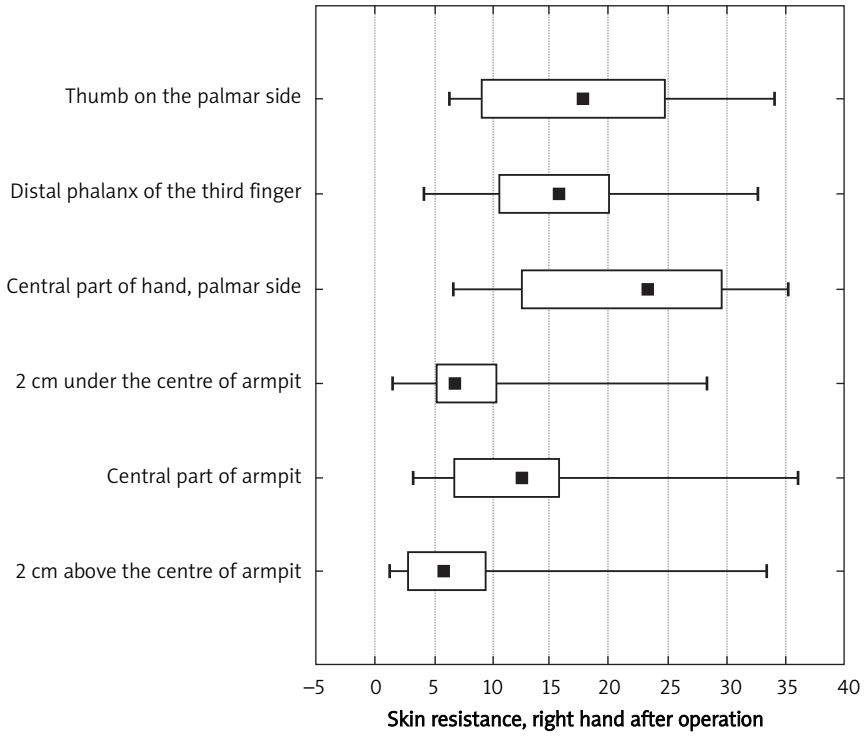

Figure 3. Skin resistance measurement on right hand after operation

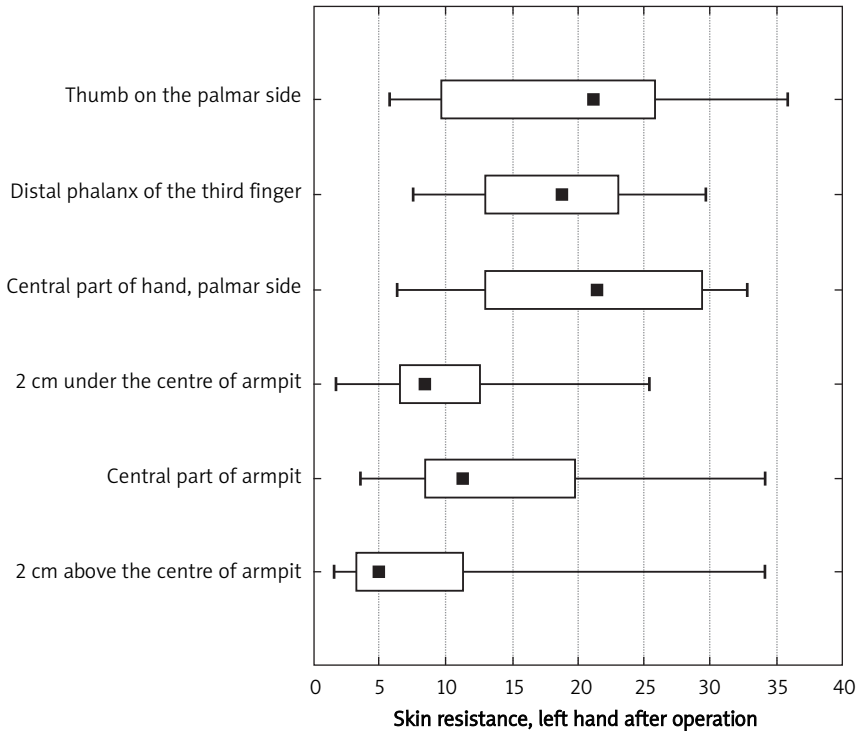

Figure 4. Skin resistance measurement on left hand after operation

$p < 0.05$ (Table IV). To check whether there was a statistically significant difference in the results before and after surgery we used sequence pairs Wilcoxon test.

In all patients we achieved the therapeutic effect of inhibiting the secretion of sweat on the hands and armpits.

Discussion

Primary hyperhidrosis is a disease connected with excessive sweat secretion, mainly in the area of the palms and armpits, although oversecretion in the sole region is also a frequent coexisting symptom. The problem concerns mainly patients of 20-30 years of age, which means the group most active professionally. The embarrassing and bothersome character of the disease frequently has a negative influence on the life and career of the patients. That is why treatment of this disease has a deep social-economic justification in spite of the lack of a direct life risk. About 25-65% of patients report occurrence of these ailments in members of their closest family. According to recent scientific reports, idiopathic hyperhidrosis is inherited in an autosomal dominant way, with variable penetration of the trait [8, 9].

There are many methods of medical treatment (antiperspirants based on aluminium chloride, anticholinergic medicines, neuroleptics, hypnosis, baths in boric acid, iontophoresis), but still their efficacy is variable (25-80%), and the duration of the therapeutic effect is usually limited to several days and depends, to a great extent, on the regularity of the applied procedures or the recommended medicines [10-15].

The greatest significance in hyperhidrosis treatment, due to their efficacy, is shown, decisively, by invasive techniques, including endoscopic thoracic sympathectomy, recognized as a "gold standard" [16]. However, due to the possibility of so-called compensatory hyperhidrosis, many authors believe that introducing this technique should be preceded by application of, at least, two less invasive methods [17-20].

One of the invasive methods that should be mentioned here is subcutaneous botulinus toxin application, the efficacy of which in the treatment of this particular disease is assessed by patients as 100% effective. The effects of the procedure last from 3 to

Table III. Comparison of results of measurements at different measurement points

Measurement point	*N*	Average	Median	Min.	Max.	Q25	Q75	SD
2 cm above centre of armpit (before operation on right hand)	20	0.84	0.83	0.11	2.74	0.45	1.02	0.60
2 cm above centre of armpit (after operation on right hand)	20	7.93	6.02	1.36	33.38	2.84	9.48	7.67
2 cm above centre of armpit (before operation on left hand)	20	0.81	0.73	0.10	2.60	0.27	1.16	0.61
2 cm above centre of armpit (after operation on left hand)	20	8.49	4.99	1.68	34.09	3.28	11.24	7.75
Central part of armpit (before operation on right hand)	20	1.21	0.73	0.18	4.52	0.29	1.69	1.29
Central part of armpit (after operation on right hand)	20	14.21	12.80	3.19	35.97	6.78	15.72	9.70
Central part of armpit (before operation on left hand)	20	1.23	0.78	0.20	4.40	0.33	1.71	1.18
Central part of armpit (after operation on left hand)	20	14.18	11.35	3.69	34.08	8.41	19.90	8.97
2 cm under centre of armpit (before operation on right hand)	20	1.23	0.96	0.14	4.69	0.76	1.26	1.03
2 cm under centre of armpit (after operation on right hand)	20	9.50	6.93	1.65	28.29	5.25	10.20	7.26
2 cm under centre of armpit (before operation on left hand)	20	1.48	1.13	0.17	5.55	0.82	1.71	1.16
2 cm under centre of armpit (after operation on left hand)	20	10.26	8.58	1.88	25.36	6.45	12.66	6.26
Central part of hand palmar side (right hand before operation)	20	1.00	0.61	0.18	3.98	0.25	1.22	1.13
Central part of hand palmar side (right hand after operation)	20	21.44	23.42	6.69	35.18	12.54	29.56	9.31
Central part of hand palmar side (left hand before operation)	20	1.33	0.66	0.16	4.63	0.26	2.27	1.50
Central part of hand palmar side (left hand after operation)	20	20.80	21.56	6.22	32.68	13.03	29.46	8.73
Distal phalanx of third finger (right hand before operation)	20	1.10	0.73	0.25	3.44	0.59	1.23	0.97
Distal phalanx of third finger (right hand after operation)	20	16.41	15.87	4.19	32.69	10.42	19.87	8.04
Distal phalanx of third finger (left hand before operation)	20	1.44	1.05	0.20	4.88	0.65	1.50	1.31

Table III. Cont.

Measurement point	*N*	Average	Median	Min.	Max.	Q25	Q75	SD
Distal phalanx of third finger (left hand after operation)	20	18.32	18.97	7.38	29.49	12.84	23.07	6.32
Thumb on palmar side (right hand before operation)	20	1.21	0.73	0.17	5.15	0.57	1.17	1.33
Thumb on palmar side (right hand after operation)	20	18.26	17.91	6.24	33.95	8.95	24.86	9.28
Thumb on palmar side (left hand before operation)	20	1.30	0.84	0.20	4.43	0.53	1.38	1.29
Thumb on palmar side (left hand after operation)	20	19.32	21.32	5.75	35.80	9.67	25.89	8.70

6 months; however, the interval between consecutive applications needs to be shortened due to production of natural antibodies by patients, the antibodies against exotoxin type A. Moreover, the accessibility of the procedure is limited due to the cost of this medicine and the procedure itself incurred directly by the patient (lack of NHS refund) [10, 14, 21, 22].

As far as the procedure of thoracic sympathectomy is concerned, there are numerous modifications and techniques of its performance. Kopelman and

Table IV. Results of statistical measurements made with the assumption $p < 0.05$

Compared variables	Value of *p*
2 cm above centre of armpit (before operation on right hand) and 2 cm above centre of armpit (after operation on right hand)	0.0001
2 cm above centre of armpit (before operation on left hand) and 2 cm above centre of armpit (after operation on left hand)	0.0001
Central part of armpit (before operation on right hand) and central part of armpit (after operation on right hand)	0.0001
Central part of armpit (before operation on left hand) and central part of armpit (after operation on left hand)	0.0001
2 cm under centre of armpit (before operation on right hand) and 2 cm under centre of armpit (after operation on right hand)	0.0001
2 cm under centre of armpit (before operation on left hand) and 2 cm under centre of armpit (after operation on left hand)	0.0001
Central part of hand palmar side (right hand before operation) and central part of hand palmar side (right hand after operation)	0.0001
Central part of hand palmar side (left hand before operation) and central part of hand palmar side (left hand after operation)	0.0001
Distal phalanx of third finger (right hand before operation) and distal phalanx of third finger (right hand after operation)	0.0001
Distal phalanx of third finger (left hand before operation) and distal phalanx of third finger (left hand after operation)	0.0001
Thumb on palmar side (right hand before operation) and thumb on palmar side (right hand after operation)	0.0001
Thumb on palmar side (left hand before operation) and thumb on palmar side (left hand after operation)	0.0001

Hashmonai reviewed the publications concerning thoracic sympathectomy carried out in primary hyperhidrosis which appeared in the Medline database in the years 1990-2006. In the above articles they identified 42 techniques of performing this procedure and based on the analysis of such extensive material they stated that lowering the resection level, ablation, clipping (i.e. leaving the Th2 ganglion untouched) and limiting the extent of the procedure (lack of resection, ablation or clipping below Th3, Th4 ganglions) do not affect the percentage increase in compensatory hyperhidrosis incidence [23]. As far as our centre is concerned, we apply the technique with two working ports of 10 mm and 5 mm, which gives us a surprisingly good cosmetic effect and does not limit the visibility and range of the movements performed, which can constitute a problem in the case of greater equipment miniaturization and performing the operation via a single working port [24].

Similarly to many other authors, we assumed that Th2 and Th3 ganglions are responsible for hand innervations (with a superior Th2 function that was confirmed by the research of Chuang *et al.* [25]). In the case of disorders within the face, many authors perform Th2 resection, often together with resection of 1/3 of the lower pole of the "stellate ganglion". In the case of palm and armpit hyperhidrosis, resection of Th2 and Th4 ganglions is recommended, while Yilmaz *et al.* widen the procedure range to Th5 [26-28].

During the operation we excised Th2-Th4 ganglions, as, like other surgeons [29], we think that this form promises the greatest certainty as to the radicalness of the procedure (each time the obtained sample is sent for histopathological examination [30]). Resection prevents the possible regeneration of nerve fibres, which is the most frequent cause (in case of less invasive procedures, non-radicalness of the surgery) of fast recurrence of excessive sweating [29, 31]. In order to increase the probability of operation radicalness, each time the parietal pleura was delaminated at the distance of 3 cm (similarly to Gossort *et al.*) [31] in a line parallel to the sympathetic trunk from T2 height to Th4 in search of additional Kuntz fibres [5, 29, 32]. In the studied group, 40 sympathectomies were performed; the presence of additional fibres was found during 27 operations, which constitutes 67.5% (the number of described additional fibres in the literature ranges from about 40% up to 95%, which proves the great variability of the anatomy of this system) [33, 34].

Many authors, in order to evaluate the efficacy of the sympathectomy procedure, use constant skin temperature monitoring, pulse oximetry wave or even thermovision cameras. In our clinic we performed fairly precise and extensive resection surgery, the efficacy of which was confirmed by a routine Minor test and additionally performed measurement of skin resistance.

In the presented group, outstanding results were obtained already in the first 24 h after the operation. The palms of patients were dry, well warmed, and a Minor test confirmed complete limitation of excessive sweating. We obtained the expected therapeutic effect of inhibition of sweat secretion within palms and armpits (100%) in all patients. In the available literature the efficacy is in the range of 82-100% [5, 35, 36]. None of the patients reported vestigial sweating presence. In order to evaluate procedure efficacy we used the measurement of skin resistance at determined measurement points. The highest resistance increase occurred in the central palmar part after the procedure on both right and left sides (median-right 23.42 Mohm, median-left 21.56 Mohm). The lowest increase was reported at measurement point 1, on both the right and left side (median-left 4.99 Mohm, median-right 6.02 Mohm). At all measurement points we found a statistically significant increase of resistance level after the procedure.

Conclusions

Skin resistance measurement is a good method of assessing the effectiveness of early thoracic sympathectomy for primary hyperhidrosis. We have planned further measurements in the study group after 6 months and 5 years to assess the durability of the therapeutic effect.

References

1. Katara AN, Domino JP, Cheah WK, et al. Comparing T2 and T2-T3 ablation in thoracoscopic sympathectomy for palmar hyperhidrosis: a randomized control trial. Surg Endosc 2007; 21: 1768-71.
2. Hashmonai M, Kopelman D. History of sympathetic surgery. Clin Auton Res 2003; 13: 6-9.
3. Kux E. The endoscopic approach to the vegetative nervous system and its therapeutic possibilities, especially in duodenal ulcer, angina pectoris, hypertension and diabetes. Dis Chest 1951; 20: 139-47.
4. Kux E. The transpleural endoscopic approach to the autonomic nervous system and its therapeutic possibilities. Chest 1949; 16: 625-6.

5. Hashmonai M, Assalia A, Kopelman D. Thoracoscopic sympathectomy for palmar hyperhidrosis: ablate or resect? Surg Endosc 2001; 15: 435-41.
6. Schlereth T, Dieterich M, Birklein F. Hyperhidrosis: causes and treatment of enhanced sweating. Dtsch Arztebl Int 2009; 106: 32-7.
7. Winckiewicz W, Bucko W, Stanisic MG, et al. Role of thoracoscopic sympathectomy in hyperhidrosis of upper limbs: early and late results. Postep Derm Alergol 2005; 23: 199-205.
8. Eisenach JH, Atkinson JL, Fealey RD. Hyperhidrosis: evolving therapies for a well-established phenomenon. Mayo Clin Proc 2005; 80: 657-66.
9. Murphy M, Ghosh J, Khwaja N, et al. Upper dorsal endoscopic thoracic sypathectomy: a comparison of one- and two-port ablation techniques. Eur J Cardiothorac Surg 2006; 30: 223-7.
10. Batra RS, Dover JS, Arndt KA. Adverse event reporting for botulinum toxin type A. J Am Acad Dermatol 2005; 53: 1080-2.
11. Benohanian A. What stands in the way of treating palmar hyperhidrosis as effectively as axillary hyperhidrosis with botulinum toxin type A. Dermatol Online J 2009; 15: 12.
12. Commons GW, Lim AF. Treatment of axillary hyperhidrosis/bromidrosis using VASER ultrasound. Aesthetic Plast Surg 2009; 33: 312-23.
13. Lefrandt JD, Maurer JM. Oxybutynin for hyperhidrosis. Neth J Med 2007; 65: 356.
14. Nelson L, Bachoo P, Holmes J. Botulinum toxin type B: a new therapy for axillary hyperhidrosis. Br J Plast Surg 2005; 58: 228-32.
15. Thomas I, Brown J, Vafaie J, Schwartz RA. Palmoplantar hyperhidrosis: a therapeutic challenge. Am Fam Physician 2004; 69: 1117-20.
16. Murphy M, Ghosh J, Khwaja N, et al. Upper dorsal endoscopic thoracic sypathectomy: a comparison of one- and two-port ablation technigues. Eur J Cardiothorac Surg 2006; 30: 223-7.
17. Eisenach JH, Atkinson JL, Fealey RD. Hyperhidrosis: evolving therapies for a well-established phenomenon. Mayo Clin Proc 2005; 80: 657-66.
18. Katara AN, Domino JP, Cheah WK, et al. Comparing T2 and T2-T3 ablation in thoracoscopic sympathectomy for palmar hyperhidrosis: a randomized controltrial. Surg Endosc 2007; 21: 1768-71.
19. Reisfeld R, Eisenach JH, Atkinson JLD, et al. Who chooses the appropriate treatment for hyperhidrosis-physician and patient, or insurer? Mayo Clin Proceedings 2006; 81: 262.
20. Stefaniak T, Pirski MI, Osęka T, et al. Simultaneous bilateral transthoracic sympathectomy through posterior access in Lin-Telaranta modification for primary hyperhidrosis. Videosurgery Miniinv 2009; 4: 47-52.
21. Batra RS, Dover JS, Arndt KA. Adverse event reporting for botulinum toxin type A. J Am Acad Dermatol 2005; 53: 1080-2.
22. Benohanian A. What stands in the way of treating palmar hyperhidrosis as effectively as axillary hyperhidrosis with botulinum toxin type A. Dermatol Online J 2009; 15: 12.
23. Kopelman D, Hashmonai M. The correlation between the method of sympathetic ablation for palmar hyperhidrosis and the occurrence of compensatory hyperhidrosis: a review. World J Surg 2008; 32: 2343-56.
24. Georghiou GP, Berman M, Bobovnikov V, et al. Minimally invasive thoracoscopic sympathectomy for palmar hyperhidrosis via a transaxillary single-port approach. Interact Cardiovasc Thorac Surg 2004; 3: 437-41.
25. Chuang TY, Yen YS, Chiu JW, et al. Intraoperative monitoring of skin temperature changes of hands before, during, and after endoscopic thoracic sympathectomy: using infrared thermograph and thermometr for measurement. Arch Phys Med Rehabil 1997; 78: 85-8.
26. Cho HM, Chung KY, Kim DJ, et al. The comparison of VATS ramicotomy and VATS sympathicotomy for treating essential hyperhidrosis. Yonsei Med J 2003; 44: 1008-13.
27. Lardonis D, Ris HB. Minimally invasive video-endoscopic sympathectomy by use of a transaxillary single port approach. Eur J Cardiothorac Surg 2002; 21: 67-70.
28. Malmivaara A, Kuukasjärvi P, Autti-Ramo I, et al. Effectiveness and safety of endoscopic thoracic sympathectomy for excessive sweating and facial blushing: a systematic review. Int J Technol Assess Health Care 2007; 23: 54-62.
29. Doblas M, Gutierrez R, Fontcuberta J, et al. Thoracodorsal sympathectomy for severe hyperhydrosis: posterior bilateral versus unilateral staged sympathectomy. Ann Vasc Surg 2003; 17: 97-102.
30. Rthinam S, Nanjaiah P, Sivalingam S, Rajesh PB. Excision of sympathetic ganglia and the rami communicantes with histological confirmation offers better early and late outcomes in video assisted thoracoscopic sympathectomy. J Cardiothorac Surg 2008; 3: 50.
31. Lee DY, Paik HC, Kim DH, Kim HW. Comparative analysis of t3 selective division of rami communicantes (ramicotomy) to t3 sympathetic clipping in treatment of palmar hyperhidrosis. Clin Auton Res 2003; 13: 45-7.
32. Fibla JJ, Molins L, Mier JM, Vidal G. Effectiveness of sympathetic block by clipping in the treatment of hyperhidrosis and facial blushing. Interact Cardiovasc Thorac Surg 2009; 9: 970-2.
33. Cho HM, Lee DY, Sung SW. Anatomical variations of rami communicantes in the upper thoracic sympathetic trunk. Eur J Cardiothorac Surg 2005; 27: 320-4.
34. Singh B, Ramsaroop L, Partab P, et al. Anatomical variations of the second thoracic ganglion. Surg Radiol Anat 2005; 27: 119-22.
35. Chou SH, Kao EL, Li HP, et al. T4 sympathectomy for palmar hyperhidrosis: an effective approach that simultaneously minimizes compensatory hyperhidrosis. Kaohsiung J Med Sci 2005; 21: 310-3.
36. Kim DH, Paik HC, Lee DY. Video assisted thoracoscopic re-sympathetic surgery in the treatment of re-sweating hyperhidrosis. Eur J Cardiothorac Surg 2005; 27: 741-4.