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Endoscopic thoracic sympathicotomy for primary palmar hyperhidrosis: A retrospective multicenter study in China

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ABSTRACT

Background: This study aimed to evaluate the clinical efficacy and safety of endoscopic thoracic sympathicotomy and to explore strategies to decrease the incidence of transfer hyperhidrosis (TH).
Methods: From January 2003 to July 2016, 10,275 patients with primary palmar hyperhidrosis underwent endoscopic thoracic sympathicotomy in 15 different institutions. We carried out a retrospective analysis of these patients who were grouped into group A, those with nonretained R2 (R2, R2–3, or R2–4 ablation), and group B, those with retained R2 (single R3 or R4 ablation).
Results: All procedures were performed successfully. Both hands of all patients became warm and dry immediately after endoscopic thoracic sympathicotomy. Pneumothorax occurred in 146 patients, and 39 patients had intraoperative bleeding. Follow-up was carried out from 6 months to 13 years. A total of 531 patients (5.2%) were lost to follow-up. The effective rate for primary palmar hyperhidrosis was 100%. Palmar hyperhidrosis recurred in 73 patients (0.7%). Transfer hyperhidrosis appeared in 7,678 patients (78.8%). For groups A and B, the incidence of TH was 80.4% and 78.5%, respectively ($P > .05$), but the incidence of grade III+IV TH in group B (1.6%) was less than that in group A (4.8%; $P < .001$).
Conclusion: Endoscopic thoracic sympathicotomy is a minimally invasive, safe, and effective therapeutic method for primary palmar hyperhidrosis. Although the overall incidence of TH is high, the incidence of grade III to IV TH can be decreased by reserving R2, lowering the level of thoracic sympathicotomy, and single severing of R3 or R4.

Introduction

Primary palmar hyperhidrosis (PPH) refers to the excessive secretion of exocrine glands on the palms, which is often accompanied by head, face, armpit, or plantar hyperhidrosis.[1] PPH demonstrates no obvious organic cause; however, some patients may

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feel distressed because their palms sweat more than normal, and such a situation may lead to severe psychologic, social, and occupational dysfunction.[2] In Western countries, the prevalence of PPH is about 0.6% to 1.0%.[3,4] In 2010, we conducted a national survey and found that the PPH prevalence rate of adolescents was 2.1% in mainland China.[5] Some literature reported that endoscopic thoracic sympathicotomy (ETS) is a safe and effective means to treat PPH.[6,7] Transfer hyperhidrosis (TH), when body parts (such as trunk or lower limbs) that are normal before surgery may sweat excessively after the operation is, however, the most undesirable side effect of ETS. TH occurs in the literature in about 3% to 98% of patients[7] and can be quite bothersome to these patients. Therefore, we still need more data from multicenter studies to re-evaluate the clinical efficacy and safety of ETS and to explore strategies to decrease the incidence of TH.

In this article, we analyzed retrospectively the clinical data of 15 institutions from a Chinese Expert Committee on Palmar Hyperhidrosis in the past 13 years.

Methods

Patients

From January 2003 to July 2016, 10,275 PPH patients underwent ETS in these 15 institutions. This group comprised 5,318 men and 4,957 women aged between 16 and 62 years with an average age of 22.5 years. Both palms of patients suddenly developed excessive sweat without any known cause, accompanied by hyperhidrosis of one or more body parts (Table I); this reaction was exacerbated by high outside temperatures or emotional stress in particular. Within these PPH patients, 865 cases (8.4%) were accompanied by chapped palms, eczema, pompholyx, and other skin diseases. According to the classification criteria of palmar hyperhidrosis,[8] there were 9,178 severe cases (when palms sweat, the sweat is in the shape of drops), 1,097 moderate cases (when palms sweat, a handkerchief can be drenched), and no mild cases (palms sweat and are moist). Among these patients, 2,609 patients (25.4%) had a positive family history of hyperhidrosis. There were 8,149 cases (79.3%) with onset of disease in childhood, 1,223 cases (11.9%) with onset of disease in adolescence, and 903 (8.8%) with an uncertain time of onset. There were 2,551 cases (24.8%) who received nonoperative treatment, which was ineffective. The excessive sweating of all patients disturbed their daily life, work, and social activities. Criteria for inclusion were age $\geq$16 years and $\leq$65 years, moderate and severe PPH, body mass index <28, and resting heart rate >55 beats/min. Criteria for exclusion were patients with severe pleural adhesions; palmar hyperhidrosis accompanied by profuse perspiration of trunk, groin, or thigh; plantar, axillary hyperhidrosis without palmar hyperhidrosis; and secondary hyperhidrosis including tuberculosis, hyperthyroidism, and other endocrine diseases.

Operative procedure

Four types of general anesthesia (Table II) were used. During the intraoperative period, heart rate, blood pressure, blood oxygen saturation, and palm temperature were monitored routinely. Operative positions were lateral before June 2007 and semi-sitting (Fig 1) thereafter. A 2-port or single-port incisions (Fig 2) on the lateral walls of the chest (periareolar[9] or axillary[10] incision) were selected, followed by insertion of a 5-mm or 3-mm, 30 degree thoracoscope into the chest cavity. The upper part of the thoracic sympathetic nerve chain on the respective ribs at the thoracic apex was sought, and electrocauterization was used to cut the nerve chain. To clarify the cutting plane of the nerve chain, the surgeons adopted internationally defined terminologies and standard operative records to use R instead of T, for example, R3 (R refers to the ribs, and 3 refers to the third rib, Fig 3); this terminology was used instead of T3.[7] Among 10,275 cases, ETSs were divided into group A (1,646 cases), with nonretained R2 in which R2 was transected as follows (381 cases of R2 ablation, 686 cases of R2–3, and 579 cases of R2–4 ablation) and group B (8,629 cases), with retained R2 (6,033 cases of single R3 ablation and 2,596 cases of single R4 ablation, Fig 4). There were no obvious differences in the incidence of axillary and plantar hyperhidrosis or skin disorders between the 2 groups.

Table I
Patient characteristics (location of hyperhidrosis)

Body part	n	%
P only	2,723	26.5
P+C	587	5.7
P+A	1,574	15.3
P+PL	3,115	30.3
P+A+PL	1,358	13.2
P+C+A+PL	918	8.9
Total	10,275	100

A, axilla; *C*, head and face; *P*, palm; *PL*, plantar.

Criteria for evaluation of therapeutic effects

Treatment is effective if palmar skin becomes dry, with the palmar skin temperature postoperatively of patients being 1°C greater than that preoperatively. Patients comprehensively evaluated their degree of satisfaction regarding postoperative curative effect and quality of life by comparing the level of their physiologic problems in their preoperative life, work, and social activities with the postoperative level.

Data collection and follow-up

The operative time, blood oxygen saturation, resolution of palmar hyperhidrosis, increase in palmar temperature, and complications were collected after the ETS. Patients were followed-up by outpatient return visits, questionnaire surveys, filing out of online forms, and telephone. The components of follow-up questionnaire are listed in Table III. In this study, the 3-level traditional compensatory hyperhidrosis (CH) is renamed as transfer hyperhidrosis (TH) and is divided into 4 grades (Table III).

Statistics and analysis

The χ^2 test was adopted to compare the differences in postoperative TH between groups A and B using the statistical package SPSS 18.0 (SPSS, Chicago).

Results

In the 10,275 patients who underwent ETS, both the preoperative and postoperative degree of blood oxygen saturation showed no change, and all operations were performed and completed successfully via a thoracoscopic approach. After the operation, the profuse sweating resolved in all patients immediately, both hands became dry and warm, and the mean postoperative palm temperature was greater (3.6° ± 1.5°C). Overall the unilateral operation time was 10 to 18 minutes, with an average of 13.8 minutes (the time taken from skin incision to suturing).

The postoperative complications were minor. No operative mortality, Horner syndrome, and other severe complications

Table II
Patients' anesthesia, position, and incision

Anesthesia	Position		Incision (%)			
			Double		Single	
	90° Lateral	45° Semi-sitting	Axilla	Axilla+Areola	Areola	Axilla
Double-lumen	2,231 (21.7)	0 (0)	2,231 (21.7)	0 (0)	0 (0)	0 (0)
Single-lumen	0 (0)	6,412 (62.4)	996 (9.7)	268 (2.6)	432 (4.2)	4,716 (45.9)
Laryngeal mask	0 (0)	1,470 (14.3)	238 (2.3)	81 (0.8)	165 (1.6)	986 (9.6)
Facial mask	0 (0)	162 (1.6)	11 (.1)	8 (.1)	28 (.3)	115 (1.1)

Fig 1. Since 2007, all patients have been placed on the operating table in a semi-sitting position, so a sequential bilateral procedure can be performed without repositioning.

occurred in any patient, no patients developed a wound infection, and on average, the patients were hospitalized for <2 days. Pneumothorax was found on the postoperative chest x-ray in 146 patients (1.4%), which was treated by observation or drainage. Hemorrhage during the operation occurred in 39 patients (0.4%), among whom a branch of the azygos vein bleed in 2 patients whose bleeding volume within 1 minute was 300 to 500 mL; titanium clips were applied immediately to occlude the vein to successfully stop bleeding. Slight bleeding occurred in the remaining 37 patients with hemorrhage, whose bleeding was stopped by electrocoagulation. A thoracotomy tube was placed inside the chest of 85 patients (on 1 side of 68 patients and on 2 sides of 17 patients) because of separation of pleural adhesions, resection of bullae of the lung, intraoperative bleeding, persistent pulmonary leak, pneumothorax, or atelectasis. The average volume of drainage was <100 mL/day, and the tubes were removed within 1 to 3 days postoperatively.

Follow-up was completed in 9,744 patients (group A, 1,539 cases and group B, 8,205 cases); 531 patients were lost to follow-up for a loss rate of only 5.2%. Overall follow-up ranged from 6 months to 13 years (average 68.3 ± 2.5 months). Profuse sweating of palms, head, and face of all patients disappeared postoperatively, the effective rate of treatment being essentially 100%; axillary and plantar hyperhidrosis were relieved or resolved in (58.8%) and (29.3%), respectively, and skin disorders of 812 patients were mitigated or cured in all cases within 6 months. Transient postoperative palmar sweating manifested in 89 patients (0.9%) within 1 week postoperatively and resolved spontaneously in all patients within 1 to 2 weeks. Postoperative back pain occurred in 124 patients (1.3%), which resolved within 1 week with no analgesics required. Mild gustatory hyperhidrosis occurred in 13 patients (0.1%), manifested as profuse sweating of the head and face when patients ate sour, spicy, or hot food. Seventy-three patients (0.7%) developed recurrent palmar hyperhidrosis, including 11 patients (0.71%) in group A and 62 cases (0.76%) in group B, ($\chi^2 = 0.029$, $P = .864$). Among them, 21 had bilateral palmar hyperhidrosis, and 52 had single-palmar hyperhidrosis (33 cases on the right palm and 19 cases on the left palm). According to the classification criteria of palmar hyperhidrosis,[8] among these 73 patients, there were 37 severe cases, 25 moderate cases, and 11 mild cases. The shortest recurrence time was 2 months, and the greatest was 5 years and 2 months. Of these 73 patients, 35 patients were cured by reoperation to cut R2. TH occurred in 7,678 patients with an overall incidence rate of 78.8%. The difference in incidence rates of TH between groups A and B was not different; however, grades III to IV TH was more common in group A than in group B (4.8% vs 1,6%; $P < .001$; Table IV). TH mainly occurred in the trunk and lower limbs. Table V shows that the occurrence rate of postoperative risks of grade III and grade IV to patients with severe palmar hyperhidrosis is greater than that in patients with moderate palmar hyperhidrosis. The 58 patients with grade IV TH were all followed up on a long-term basis with the greatest period being 13 years, but alleviation or improvement of disease was noted in only 6 patients. The difference in postoperative efficacy between groups A and B was not different; however, the postoperative satisfaction was greater in group B than in group A (85.3% vs 77.8%; $P < .001$; Table VI).

Discussion

The pathogenesis of PPH remains unclear. PPH is seen more commonly in young persons who are Asian or East Asian, which may be associated with the EDAR370A gene mutation that is carried only by Asian individuals.[11] The author's group conducted a genetic linkage analysis[12] and found a new pathogenic gene locus (2q31.1) for PPH locked within a small chromosomal interval (5.94 Mb), thus laying the foundation for further clarification of its pathogenic gene(s). In 1927, Kuntz[13] found during an anatomic study that the function of the sweat glands of human palms is controlled by the thoracic sympathetic nerve; therefore, palmar hyperhidrosis is generally considered to be caused by the overexcitation of the sympathetic nervous supply to this region. In another study, the author's group compared the ultrastructure of the thoracic sympathetic nerve of patients with and without palmar hyperhidrosis[14] and showed the following: (1) the thickness of the myelin sheath of the sympathetic ganglion and the ratio of unmyelinated nerves to myelinated nerves were greater than those of the control group; (2) the expression of the Nrg-1mRNA regulatory factor in the thoracic sympathetic ganglion was also greater than that of the control group; and (3) regulatory factors may accelerate the high degree of myelination of the thoracic sympathetic axon of patients with PPH. A high degree of myelination and an increase in the ratio of nerve fibers is presumed to lead to an increase in both the excitability of the sympathetic nerve and

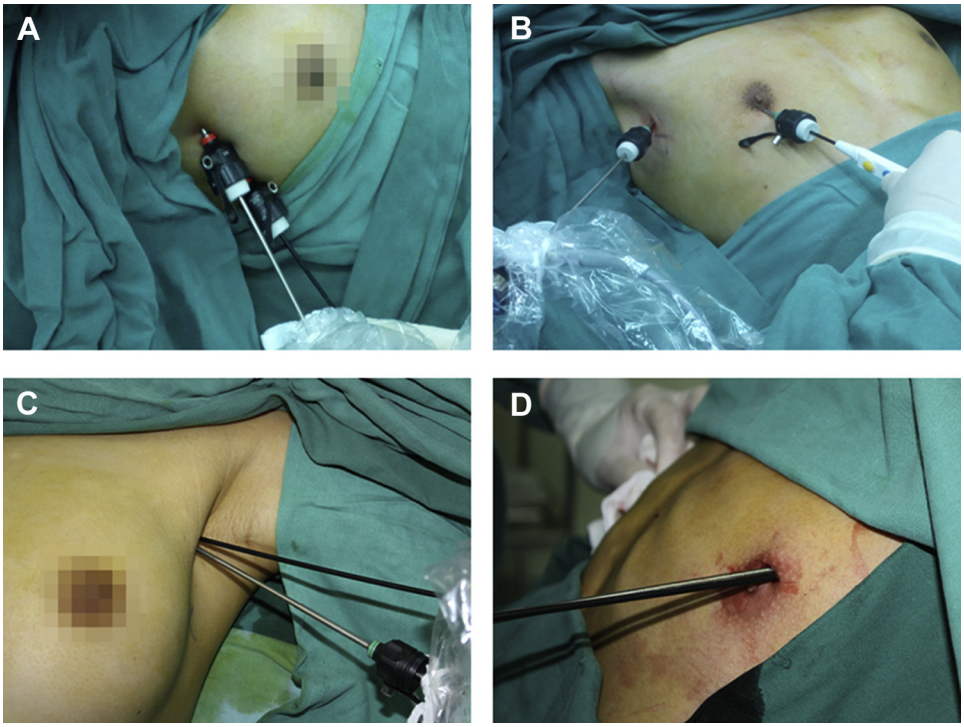

Fig 2. (*A*) Transaxillary, 2-port procedure (used for both male and female patients). (*B*) Periareolar and transaxillary, 2-port procedure (used for male patient only in our series). (*C*) Transaxillary, single-port procedure (used for both male and female patients). (*D*) Periareolar, single-port procedure (used for male patients only in our series).

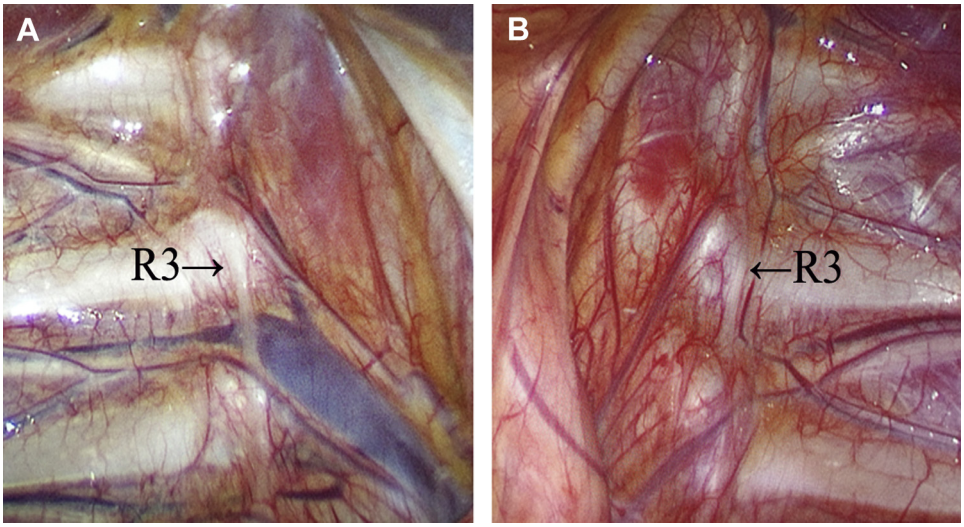

Fig 3. (*A*) Thoracoscopic view of R3 in the right thoracic cavity. (*B*) Thoracoscopic view of R3 in the left thoracic cavity.

the conduction velocity, the manifestation of which is excessive sweating of the palm in a short time. The pathologic changes described earlier may represent but one aspect of the pathogenesis of palmar hyperhidrosis.

Although the pathogenesis of PPH needs to be studied further, ETS can treat PPH effectively in the vast majority of patients with palmar hyperhidrosis. The therapeutic mechanism of ETS prevents sympathetically mediated neural impulses from reaching the palmar sweat glands by transecting the relevant thoracic sympathetic chain. According to the follow-up results, the effective cure rate of perspiration of the hands, head, and face was 100%. Patients with profuse sweating in the armpits had improvements of 58.8%, and there was improvement in 29.3% of the patients with plantar hyperhidrosis; meanwhile, any accompanying skin disorder was also mostly cured or alleviated, indicating that ETS is indeed a safe and effective treatment option for PPH patients. Recurrence of palmar hyperhidrosis after ETS is rare. In this cohort, there were 35 cases of recurrent PPH who were cured by repeating the procedure to transect R2. The reasons for recurrence may be as follows: (1) the sympathetic nerve was not completely severed; (2) the residual nerve regenerated; (3) or there was a Kuntz nerve or ramus communicans. Mild gustatory hyperhidrosis recurred in 13 cases, with clinical manifestations such as profuse sweating of the head and face while eating spicy or acidic foods. The reason for mild

Fig 4. (*A*) Thoracoscopic view of R3 ablation in the right thoracic cavity. (*B*) Thoracoscopic view of R4 ablation in the left thoracic cavity.

Table III
Follow-up questionnaire

Question response
1. State of hyperhidrosis
Head: Disappear ☐ Relieve ☐ No change ☐ Aggravate ☐
Face: Disappear ☐ Relieve ☐ No change ☐ Aggravate ☐
Armpits: Disappear ☐ Relieve ☐ No change ☐ Aggravate ☐
Palms: Disappear ☐ Relieve ☐ No change ☐ Aggravate ☐
Pelma: Disappear ☐ Relieve ☐ No change ☐ Aggravate ☐
Other body parts___: Disappear ☐ Relieve ☐ No change ☐ Aggravate ☐
2. Skin disease
Type of skin disease: chapped palm ☐ eczema ☐ pompholyx ☐ other skin disease
State of skin disease: Disappear ☐ Relieve ☐ No change ☐ Aggravate ☐
3. Recurrence of palmar hyperhidrosis
Recurrent time:____
Location: Right hand ☐ Left hand ☐
Degree*: Mild ☐ Moderate ☐ Severe ☐
4. Transfer hyperhidrosis (TH)
Occurred time:____
Location: Thorax ☐ Back ☐ Abdomen ☐ Thigh ☐ Shank ☐ Other part
Degree of TH†: I ☐ II ☐ III ☐ IV ☐
5. Satisfaction analogue visual scale
Degree: Very satisfied (9–10) ☐ Satisfied (6–8) ☐ Dissatisfied (3–5) ☐ Very dissatisfied (0–2) ☐

* According to the classification criteria of palmar hyperhidrosis.[8]

† The degree of TH was classified as follows: grade I (mild) is elicited by a hot environment, mental stress, or activity; the volume of sweat secretion is minor; and patients only feel that the skin is moist but without any discomfort. Grade II (moderate) is also elicited by a hot environment, mental stress, or activity; the volume of sweat secretion is small or moderate; patients obviously feel sweaty; and the sweat does not flow. For grade II, although patients feel discomfort, it is tolerable and not embarrassing. Grade III (severe) may appear at any time regardless of hot environment, mental stress, or activity; the volume of sweat secretion is large; and the sweat may flow. For grade III, patients need to change clothes several times a day, and may be embarrassed; the disease disturbs the life, work, and social activity of patients but is still tolerable. Grade IV (very severe) or incapacitating hyperhidrosis (IH) has clinical manifestations the same as those of grade III, seriously disturbing the life, work, and social activity of patients, but to an intolerable extent; patients almost completely lose the ability to work and regret receiving the operation.

gustatory hyperhidrosis may be associated with the excitatory hyperfunction of the parasympathetic nerve after the thoracic sympathetic nerve has been disconnected. In addition, transient postoperative palmar sweating reappeared in 89 patients within 1 week after ETS, mainly characterized by more severe or similar palm sweating in comparison with that preoperatively. With this postoperative condition, patients sweat without any inducement during both day and night, with such attacks occurring repeatedly several times a day and outbreaks ranging from minutes to hours; however, this postoperative palmar sweating was transient in all patients and resolved spontaneously within 1 to 2 weeks. The cause may be excessive secretion of sweat glands caused by transient rebound of effectors after the sympathetic innervation of sweat glands.

No severe complications occurred in any the patients in this cohort. Forty-three cases required an indwelling thoracostomy tube for pleural drainage for 1 to 2 days because of postoperative residual air. Although the reported incidence of Horner's syndrome is 0.5% to 17%,[15] no cases occurred in our study. We think that this lack of any Horner's syndrome was related to our preventive measures taken during the ETS. In group A, the thoracic sympathetic nerve was cut at the position not higher than the superior border of the second rib; this action must be quick when electrocauterization is being performed to avoid thermal conduction from affecting the stellate ganglion through the nerve chain. In group B, the thoracic sympathetic nerve of all the patients was cut at a position below R3. Although intraoperative bleeding is rare, attention must be paid to the left thoracic sympathetic nerve chain close to the aortic arch and subclavian artery, avoiding injury to blood vessels when the nerve chain is being dissected off. The left thoracic sympathetic nerve chain of one 62-year-old patient in this study was almost completely covered by a concomitant sclerosed, ectatic thoracic aorta, making the operation quite difficult; therefore, ETS may not be recommended for patients >60 years of age. The right thoracic sympathetic chain can adhere to the 2 branches of the azygos vein, namely the superior intercostal vein and posterior intercostal vein; these 2 veins and their branches often interlace with the nerve chain, forming a claw. These claw veins were injured in 2 patients during operation and lead to a bleeding of 300 to 500 mL before controlled by titanium clips.

TH is the most common side effect of ETS, and its mechanism remains unknown. Some researchers propose a generation mechanism of TH, whereby the transfer to the hypothalamus of negative feedback responsible for the inhibition of sweating is blocked.[16] In contrast, we think that TH may be associated with the sweat redistribution of the whole body as a result of the dysfunction of the afferent and efferent neurofiber impulse system after ETS. Based on the combination of 4 factors (amount of sweat, symptoms

Table IV
Incidence and grading of TH

	n	TH (%)	TH grading					
			I	II	I+II (%)	III	IV	III+IV (%)
Group A	1,539	1,237 (80.4)	602	561	1,163 (75.6)	49	25	74 (4.8)
Group B	8,205	6,441 (78.5)	3,353	2,959	6,312 (76.9)	96	33	129 (1.6)
χ^2		2.730	1.644	.085	1.342	35.853	32.718	66.529
P value		.098	.200	.771	.247	< .001	< .001	< .001

Table V
Relationship between preoperative severities of PPH with TH

	n	I (%)	II (%)	III (%)	IV (%)
Moderate	783	412 (52.6)	364 (46.5)	6 (.8)	1 (.1)
Severe	6,895	3,543 (51.4)	3,156 (45.8)	139 (2.0)	57 (.8)
χ^2		.428	.145	5.927	4.582
P value		.513	.703	.015	.032

Table VI
Postoperative efficacy and satisfaction

	n	Effective (%)	Very satisfied + satisfied (%)
Group A	1,539	1,533 (99.6)	1,198 (77.8)
Group B	8,205	8,182 (99.7)	6,998 (85.3)
χ^2		.220	53.779
P value		.639	< .001

of discomfort, degree of tolerance, and psychologic factors) of the patients in this study, we renamed this phenomenon TH and changed its 3 grades to 4 grades, which may be more objective and reasonable. Grade I patients only manifest moist skin, and they do not sweat excessively nor feel uncomfortable. Grade II patients manifest a more obvious volume of sweat but do not feel obvious discomfort. Over time, patients with grades I and II TH can gradually adapt to the situation psychologically and become adjusted, feeling that the conditions are improving by themselves. In contrast, patients in grades III and IV produce much greater volumes of sweat that flows, requiring them to change clothes several times a day. The daily life of grade III patients is affected, but it is still somewhat tolerable, and they can still participate in social activities. We term grade III severe TH. There are 58 grade IV patients in the 2 groups whose daily life and social activities had been severely disrupted over a prolonged period, and whose physiology and psychologic state were severely injured. They felt extremely pessimistic and despairing, had almost completely lost their ability to work, had given up on socializing, and were very regretful to having undergone the original ETS, even having a tendency to attempt suicide or harm the medical personnel. Therefore, we term grade IV TH incapacitating hyperhidrosis. This new classification and grading strictly differentiate grade III and the new grade IV, aiming to warn both surgeon and patient that any surgical option should be selected with extreme prudence.

The overall incidence of TH in this cohort reached 78.8%; however, the incidence of grade III+IV TH was less in group B (1.6%) than that in group A (4.8%). Our experience is to take preventive measures as follows: (1) Adopt a modified operative method as follows:[17] do not cut R2, lower the cutting plane, and decrease the number of nerve chains to be severed, that is, cut only R3 or R4[18]; (2) Strictly select patients for the operation; patients with hyperhidrosis of multiple parts of the body shall be considered as contraindicated for ETS.

Why does such a big gap exist between the incidence rates (3%–100%)[19–25] of TH? We think that several potential factors account for this difference as follows: (1) there is no unified, standard technique to measure the volume of sweat; (2) contents of questionnaires developed by different medical centers and clinicians are different and, moreover, there are no stringent grading standards; (3) patients answer questions often based largely on subjective judgments; and (4) in different seasons, patients' subjective feelings differ, which leads to different results. In view of the aforementioned reasons, it is necessary to establish a set of unified, objective indicators for scientific data analysis.

Before undergoing ETS, all the patients in this study were placed under general anesthesia, for which a facial mask or laryngeal mask was adopted for 1,632 patients who also achieved good results. It is not required to lift the epiglottis when either of these 2 methods is adopted, and the masks can be placed and removed easily, decreasing complications caused by mechanical injury to the glottis and trachea; furthermore, neither cough nor irritability tends to occur after the operation. The risk of hemodynamic disturbances is greatly decreased because of the minor stimulation and influence on blood pressure and heart rate; therefore, general anesthesia using a facial mask or laryngeal mask offers a useful alternative.

The minimal access incision has become highly sought after by the contemporary younger population. To meet the needs of these patients, the number of incisions has been decreased from the initial 3-port or 2-port to a single-port incision in recent years. The single-port approach via a periareolar or axillary incision is well received and praised by young patients. In particular, a periareolar incision is more advantageous than the traditional incision in the lateral chest wall; the areola is situated between the third and fourth anterior rib on the body surface, just opposite the third and fourth posterior rib, which is much more conducive to exposure; and transection of R3 and R4 via the thoracoscopic approach. In women, however, an axillary approach may be better appreciated.

In conclusion, EST is a safe, effective, and minimally invasive treatment for PPH. Patients in this study were very satisfied with the postoperative results; however, the incidence of postoperative TH is as great as 78.8%. This incidence of TH decreases the degree of satisfaction of some patients with respect to their quality of life issues. Therefore, strict selection of indications and adequate preoperative communication with patients are particularly important. For simple palmar hyperhidrosis, or palmar hyperhidrosis accompanied by hyperhidrosis of the head, face, armpit, and foot, preservation of R2, lowering the level of thoracic sympathicotomy, and single severing of R3 or R4 can decrease the incidence rate of severe TH and incapacitating hyperhidrosis. Simple focal hyperhidrosis, such as axillary hyperhidrosis and plantar hyperhidrosis without palmar hyperhidrosis, should be approached with extreme prudence by both surgeon and patient because of its uncertain efficacy.

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Conflict of interest/Disclosure

The authors have indicated that they have no conflicts of interest regarding the content of this article.

References

1. Sato K, Kang WH, Saga K, Sato KT. Biology of sweat glands and their disorders. II. Disorders of sweat gland function. *J Am Acad Dermatol*. 1989;20:713–726.
2. De Campos JR, Kauffman P, Werebe Ede C, et al. Quality of life, before and after thoracic sympathectomy: Report on 378 operated patients. *Ann Thorac Surg*. 2003;76:886–891.
3. Malone PS, Cameron AE, Rennie JA. Endoscopic thoracic sympathectomy in the treatment of upper limb hyperhidrosis. *Ann R Coll Surg Engl*. 1986;68:93–94.
4. Heckmann M, Plewig G, Hyperhidrosis Study Group. Low-dose efficacy of botulinum toxin a for axillary hyperhidrosis: A randomized, side-by-side, open-label study. *Arch Dermatol*. 2005;141:1255–1259.
5. Lai FC, Tu YR, Li YP, et al. Nation-wide epidemiological survey of primary palmar hyperhidrosis in the People's Republic of China. *Clin Auton Res*. 2015;25:105–108.
6. Krasna MJ. Thoracoscopic sympathectomy: A standardized approach to therapy for hyperhidrosis. *Ann Thorac Surg*. 2008;85:S764–S767.
7. Cerfolio RJ, De Campos JR, Bryant AS, et al. The society of thoracic surgeons expert consensus for the surgical treatment of hyperhidrosis. *Ann Thorac Surg*. 2011;91:1642–1648.
8. Lai YT, Yang LH, Chio CC, Chen HH. Complications in patients with palmar hyperhidrosis treated with transthoracic endoscopic sympathectomy. *Neurosurgery*. 1997;41:110–113; discussion 113–115.
9. Chen JF, Lin JB, Tu YR, Lin M, Li X, Lai FC, et al. Nonintubated transareolar single-port thoracic sympathicotomy with a needle scope in a series of 85 male patients. *Surg Endosc*. 2016;30:3447–3453.
10. Lin M, Tu YR, Lai FC, et al. Transaxillary concealing single incision endoscopic thoracic sympathectomy in the treatment of palmar hyperhidrosis: A novel surgical approach. *Zhonghua Yi Xue Za Zhi*. 2013;93:3300–3301.
11. Kamberov YG, Wang S, Tan J, et al. Modeling recent human evolution in mice by expression of a selected EDAR variant. *Cell*. 2013;152:691–702.
12. Chen J, Lin M, Chen X, et al. A novel locus for primary focal hyperhidrosis mapped on chromosome 2q31.1. *Br J Dermatol*. 2015;172:1150–1153.
13. Kuntz A. Distribution of the sympathetic rami to the brachial plexus: Its relation to sympathectomy affecting the upper extremity. *Arch Surg*. 1927;15:871–877.
14. Tu Y, Luo R, Li X, Lin M, Qiu M. Hypermyelination and overexpression of neuregulin-1 in thoracic sympathetic nerves in patients with primary palmar hyperhidrosis. *J Clin Neurosci*. 2012;19:1651–1653.
15. Singh B, Moodley J, Allopi L, Cassimjee HM. Horner syndrome after sympathectomy in the thoracoscopic era. *Surg Laparosc Endosc Percutan Tech*. 2006;16:222–225.
16. Lin CC, Telaranta T. Lin-Telaranta classification: The importance of different procedures for different indications in sympathetic surgery. *Ann Chir Gynaecol*. 2001;90:161–166.
17. Li X, Tu YR, Lin M, Lai FC, Chen JF, Dai ZJ. Endoscopic thoracic sympathectomy for palmar hyperhidrosis: A randomized control trial comparing T3 and T2-4 ablation. *Ann Thorac Surg*. 2008;85:1747–1752.
18. Mahdy T, Youssef T, Elmonem HA, Omar W, Elateef AA. T4 sympathectomy for palmar hyperhidrosis: Looking for the right operation. *Surgery*. 2008;143:784–789.
19. Licht PB, Pilegaard HK. Severity of compensatory sweating after thoracoscopic sympathectomy. *Ann Thorac Surg*. 2004;78:427–431.
20. Yano M, Kiriyama M, Fukai I, et al. Endoscopic thoracic sympathectomy for palmar hyperhidrosis: Efficacy of T2 and T3 ganglion resection. *Surgery*. 2005;138:40–45.
21. Schmidt J, Bechara FG, Altmeyer P, Zirngibl H. Endoscopic thoracic sympathectomy for severe hyperhidrosis: Impact of restrictive denervation on compensatory sweating. *Ann Thorac Surg*. 2006;81:1048–1055.
22. Miller DL, Force SD. Outpatient microthoracoscopic sympathectomy for palmar hyperhidrosis. *Ann Thorac Surg*. 2007;83:1850–1853.
23. Katara AN, Domino JP, Cheah WK, So JB, Ning C, Lomanto D. Comparing T2 and T2–T3 ablation in thoracoscopic sympathectomy for palmar hyperhidrosis: A randomized control trial. *Surg Endosc*. 2007;21:1768–1771.
24. Lyra Rde M, Campos JR, Kang DW, Loureiro Mde P, Furian MB, Costa MG, et al. Guidelines for the prevention, diagnosis and treatment of compensatory hyperhidrosis. *J Bras Pneumol*. 2008;34:967–977.
25. Sugimura H, Spratt EH, Compeau CG, Kattail D, Shargail Y. Thoracoscopic sympathetic clipping for hyperhidrosis: Long-term results and reversibility. *J Thorac Cardiovasc Surg*. 2009;137:1370–1376; discussion 1376–1377.