T3-T5 Thoracoscopic sympathectomy versus sympathicotomy in the treatment of palmar–axillary–plantar hyperhidrosis

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Background
Compensatory hyperhidrosis is a common complication after thoracoscopic interruption of the sympathetic chain in hyperhidrosis patients. Nonetheless, no interruption technique has been defined to decrease the incidence of that dreadful complication. Herein, we compared T3-5 sympathectomy with sympathicotomy at the same levels with regard to postoperative outcomes.
Methods
Eighty patients diagnosed with primary palmar–axillary–plantar hyperhidrosis were randomized into two equal groups: the sympathectomy and sympathicotomy groups. They were followed up for 6 months after the procedure. The incidence and criteria of compensatory hyperhidrosis were compared between the two approaches.
Results
The sympathectomy group showed a significant prolongation of the operative time. However, postoperative pain, hospital stay, and the incidence of complications were statistically comparable between the two approaches. Both procedures were associated with a significant decline in the severity of sweating in the three regions, which was more prominent in the palmar and axillary regions compared with the foot. The incidence of compensatory hyperhidrosis was 65% in sympathectomy patients and 77.5% in sympathicotomy patients, with no significant difference between them (P=0.217). About two-thirds of these cases were temporary, and the majority of them had mild to moderate symptoms. Patient satisfaction did not differ between the two approaches, with poor satisfaction in patients with permanent compensatory hyperhidrosis.
Conclusion
Both sympathectomy and sympathicotomy had comparable outcomes in patients with palmar–axillary–plantar hyperhidrosis, manifested in comparable decreased sweating severity, incidence of compensatory hyperhidrosis, quality of life, and patient satisfaction.

Keywords:
hyperhidrosis, sympathectomy, sympathicotomy

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Introduction

Hyperhidrosis is an excessive sweating disorder that affects 1–5% of the general population [1,2], and it occurs secondary to overstimulation of eccrine gland cholinergic receptors [3]. That condition is commonly idiopathic in nature. However, it could occur secondary to a systemic illness like hyperthyroidism [4].

The idiopathic type is usually localized to certain body parts like the axilla, palms, and soles, and it is called 'primary focal hyperhidrosis' [5]. To diagnose that condition, the patient must report focal, visible excessive sweating lasting 6 months or more, in the absence of secondary causes. Additional two criteria should be fulfilled, including disease onset before the age of 25 years, bilateral symmetrical affection, one episode or more per week, a positive family history of a similar condition, absence of sweating while sleeping, and impairment of daily activities [6]. Patients usually complain of numerous negative psychosocial, occupational, and educational consequences [7].

Currently, multiple treatment modalities are available for such patients, including antiperspirants, iontophoresis, botulinum toxin injection, energy-based devices (microwave or radiofrequency), and surgical intervention [8]. Surgery is usually reserved for patients with refractory conditions after the failure of other methods. The concept of surgery is based on

the interruption of impulse transmission from the sympathetic ganglia to the eccrine sweat glands [9,10].

Regarding the surgical procedure, it is performed through thoracoscopy with multiple options for ganglion interruption, including cauterization, clipping, cutting, or segment removal. To achieve surgical success, two factors must be considered: the level of interruption and the complete division of the nerves to hinder neural regrowth [11]. Both sympathectomy (removal of a sympathetic chain segment) and sympathicotomy (simple division of the sympathetic chain) have been described as safe and effective options to manage patients with hyperhidrosis [12,13].

Despite its effectiveness, the thoracoscopic intervention has some complications, and the most distressing one is compensatory hyperhidrosis. This complication poses a major source of patient dissatisfaction after the procedure [14], and its occurrence is thought to be secondary to a dysfunctional reflex arc from the sympathetic nervous system to the hypothalamus [15,16]. Yet, no interruption technique has been defined to decrease the incidence of that dreadful complication [17].

That is why we conducted the present trial to compare the outcomes of T3-5 sympathectomy versus sympathicotomy in patients with palmar–axillary–plantar hyperhidrosis.

Patients and methods

This prospective randomized trial was performed at Mansoura University General Surgery Department over a 1-year duration, from November 2021 to November 2022, after obtaining approval from the Institutional Review Board (IRB), Mansoura Faculty of Medicine, Egypt (IRB code: R.21.11.1508). Our trial was designed for patients diagnosed with moderate-to –severe primary palmar–axillary–plantar hyperhidrosis, of either gender and whatever their age. The diagnosis of primary hyperhidrosis was done according to the criteria [6] reported in the 'introduction'section.

We used SPSS Sample Power software (version 3.0.1 for Windows) to estimate the proper sample size depending on the difference in the incidence of compensatory hyperhidrosis between the two thoracoscopic approaches. In a previous study conducted in 2015 [12], the incidence of that complication was 77.1% in the sympathectomy group, compared with 72.2% in the sympathicotomy group (about a 5% difference). Using a two-tailed test probability of 90% power and a 0.1 alpha error, the study required 36 patients to be enrolled in each group. With an expected dropout rate of 10%, the sample was increased to 40 patients in each group.

The preoperative patient assessment included detailed history taking (focusing on disease duration, affected anatomical regions, and previous treatment trials), physical examination (to exclude any associated systemic disease), routine preoperative laboratory investigations, and a detailed cardiopulmonary assessment (including, chest radiograph, electrocardiogram, and echocardiography if needed). Patients with secondary hyperhidrosis, neurological disorders (like Parkinsonism or stroke), metabolic disorders (hyperthyroidism or diabetes), or major psychiatric illnesses were excluded from our trial.

Eighty patients were found eligible for our study (according to the previous sample size). All patients were asked to subjectively express the severity of hyperhidrosis in each anatomical region according to the visual analog scale, with 0 for complete dryness and 10 for severe sweating [18]. Their quality of life (QOL) was evaluated by the Keller questionnaire [19], which assessed the impact of the disease on the patient's QOL from mild to severe (from 0 to 10). All patients were also informed how to express their pain on the Numerical Rating Scale (NRS), which is an 11-point scale, with 0 for no pain sensation and 10 for the worst pain ever [20].

The patients were randomly assigned into two groups (40 patients in each): the first group included patients who underwent sympathectomy, while the second group included patients who underwent sympathicotomy. The 'sealed envelope method' was used for randomization. All patients were informed about the aim of the research and the benefits and risks of each intervention before they signed their written consent.

Both thoracoscopic approaches were performed under general anesthesia by the same surgical team. All patients were intubated by a single-lumen endotracheal tube. The patients were positioned in the semi-Fowler position with their arms abducted for better exposure of the axilla.

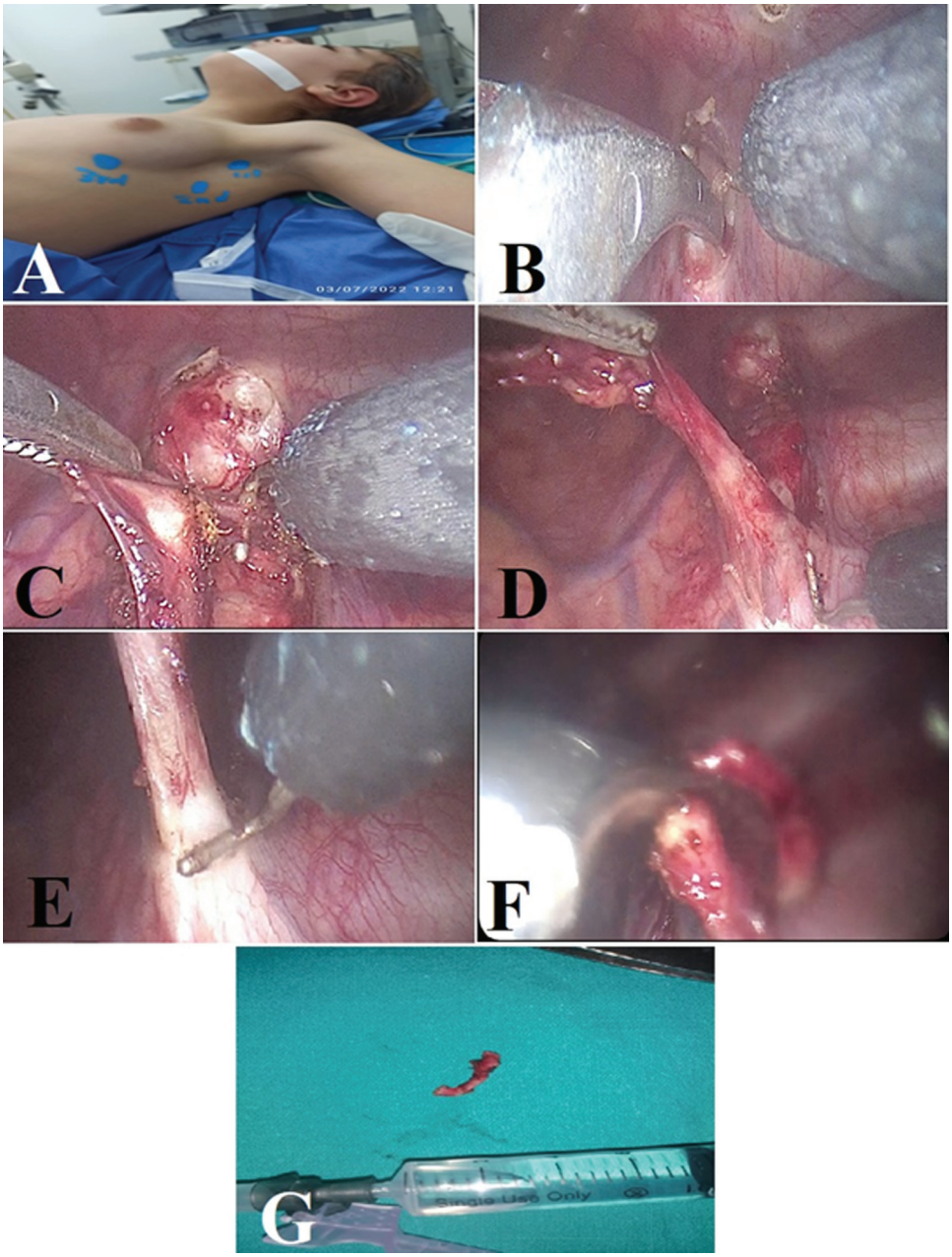
After lung deflation, three 5-mm ports were inserted in the sympathectomy group; the first blunt-ended port was inserted at the third intercostal space (ICS) at the

midaxillary line for introducing a 30-degree thoracoscope. Then, the remaining two ports were inserted under vision; one was inserted in the fourth ICS midway between the mid and posterior axillary lines, whereas the second was inserted into the following ICS in the anterior axillary line. The third, fourth, and fifth costal heads were identified, and the ganglions were identified in the corresponding ICSs. The sympathetic chain was divided at T3-5 levels and then excised. We divided the medial and lateral rami of the sympathetic chain during excision (Fig. 1).

In the sympathicotomy group, only two 5-mm ports were used. The thoracoscopic port was inserted at the same site as the sympathectomy group, while the second one was inserted under vision in the fifth ICS in the anterior axillary line. The sympathetic chain was divided at the same levels as the sympathectomy group, with 2-cm lateral extension of the ablation to destroy the Kuntz nerve (Fig. 2).

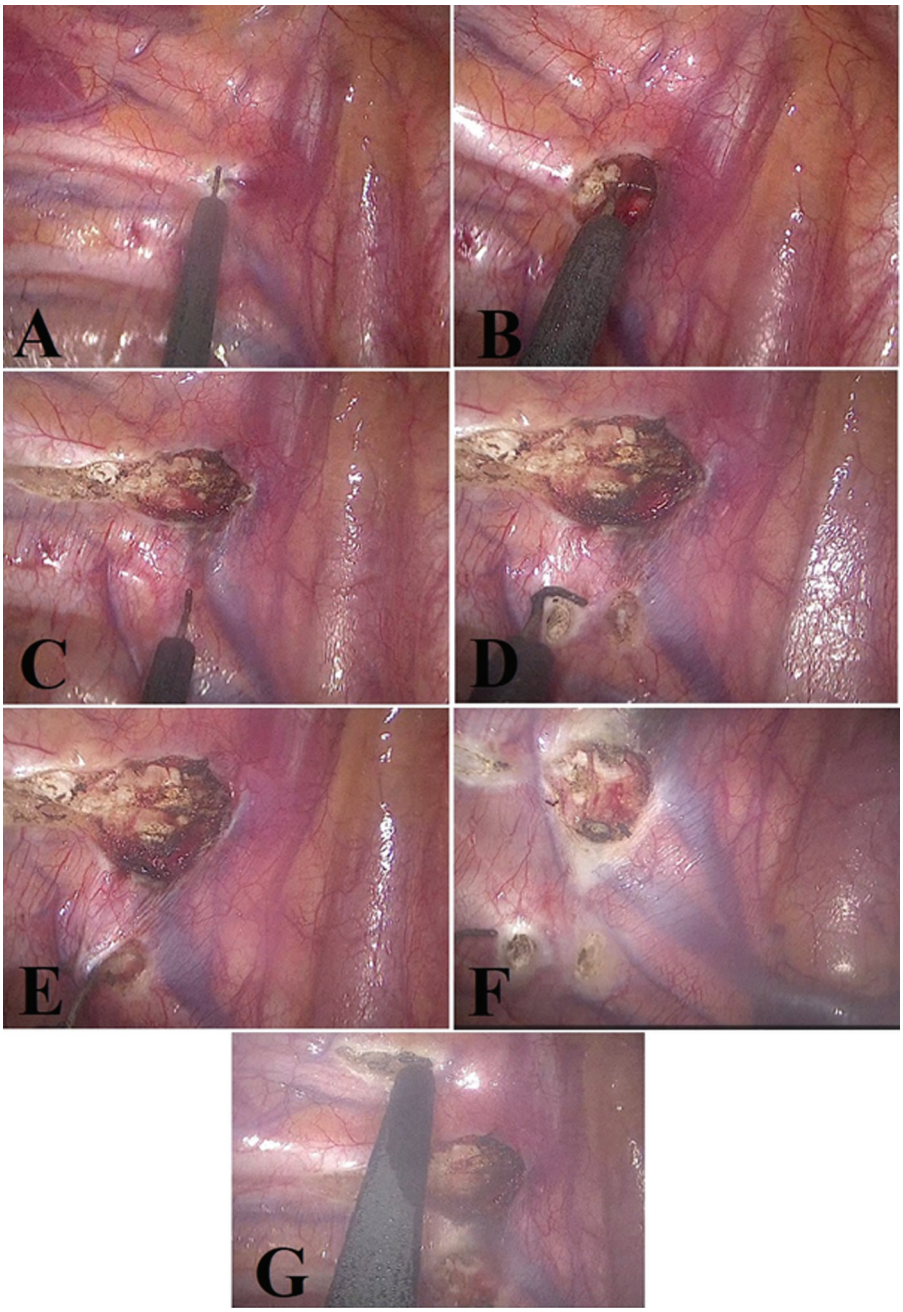
In both groups, 10 ml of local anesthesia (mixed lidocaine and bupivacaine) were injected through the

Figure 1



(A) Port position in the sympathectomy group. (B) Opening the parietal pleura and cutting the sympathetic nerve at the level of R3. (C) Proceeding with segmentectomy together with cutting of lateral rami. (D) Dissection of the sympathetic segment till reaching the level of R5. (E) Cutting and separation of sympathetic chain at the level of R5. (F) Segment removal. (G) Sympathetic segment after extraction.

Figure 2



(A) Opening the parietal pleura to delineate the sympathetic chain at the level of R3. (B) Elevation and cutting of sympathetic chain at the level of R3. (C) The 2-cm lateral extension of the ablation destroys the Kuntz nerve. (D) Opening the parietal pleura at the level of R4. (E) Cutting of sympathetic chain at the level of R4. (F) Repeating the same technique at the level of R5. (G) Ablation of nerve of Kuntz at the lateral aspect of second rib.

working port to the ablation site. Then, the working ports were removed, and the anesthesiologist was asked to inflate the lung to allow its expansion. After that, the thoracoscopic port was removed when the lung was about to reach the thoracic walls. Continuous positive pressure ventilation was maintained for a few seconds after the removal of the last port to decrease the risk of residual pneumothorax. The same procedure was then repeated on the contralateral side.

After the procedure, the patients were transferred to the recovery room and then to the internal ward, where close monitoring was achieved. A postoperative chest radiograph was done to reveal any residual pneumothorax. Postoperative pain was assessed through the NRS every 4 hours during the first postoperative day, and the mean of these readings was calculated and recorded. Most patients were discharged on the first or second postoperative day.

Follow-up visits were arranged at 2 weeks, then at 1, 3, and 6 months after the surgery. Changes in the severity of hyperhidrosis were assessed according to the VAS, while the QOL was assessed using the same preoperative questionnaire, and the 6-month readings were compared with the corresponding preoperative values. The incidence of compensatory hyperhidrosis was recorded in both groups, along with the affected site, duration, and severity. Its severity was subjectively classified as mild, moderate, or severe for not bothersome, bothersome but tolerable, and bothersome and intolerable, respectively [21]. At the last follow-up, the patients were asked to express their satisfaction according to a five-grade Likert scale as follows: poor, fair, good, very good, or excellent [22].

For research purposes, our main outcome was the incidence of postoperative compensatory hyperhidrosis (defined as perspiration in areas with a normal preoperative sweating pattern [23]), whereas secondary outcomes included operative time, changes in the severity of hyperhidrosis in the three anatomical areas, other complications, and patient satisfaction.

The analysis of the previous data was done using SPSS software (version 26 for MacOS). We expressed categorical data as numbers and percentages, which were compared between the two groups using the Chi-square test. Regarding quantitative data, it was expressed as means and standard deviations (for non-skewed variables) or medians and ranges (for skewed data). The Student-t and Mann-Whitney tests were used to compare the previous two types of data, respectively. Comparing parameters within the same group over different time points was done using the Wilcoxon-signed rank test. Any *P* value less than 0.05 was taken as significant in our analysis.

Results

The two groups expressed comparable statistical findings regarding age, gender, and body mass index (BMI) distributions. The age of sympathectomy patients ranged between 7 and 35 years (median=21), while it ranged between 8 and 35 years in the sympathicotomy group (median=20). Women represented 55% and 50% of our participants in the sympathectomy and sympathicotomy groups, respectively. Regarding BMI, it had median values of 22.7 and 22.4 kg/m2 in the same groups, respectively. Disease duration ranged between 5 and 10 years in both study groups (Table 1).

The sympathectomy group showed a significant prolongation in the operative time (46 vs. 33 min in the sympathicotomy group – $P<0.001$). The method of sympathetic chain interruption was comparable between the two groups, as we depended on the hook tool in most cases, while scissors were used in only three cases in the sympathectomy group and five cases in the sympathicotomy group (Table 2).

The postoperative pain score ranged between four and seven on the NRS in the two groups ($P=0.083$). No patients in either group developed Horner syndrome or hemothorax. Pneumothorax occurred in two patients in each group, and it was detected only in the postoperative radiograph with no clinical manifestations and showed spontaneous resolution with no need for a catheter or tube thoracostomy. Surgical emphysema was encountered in 12.5% of sympathectomy patients compared with 10% of sympathicotomy patients ($P=0.723$). Cases with surgical emphysema were minimal to mild and not

Table 1 Basic demographic and clinical data of the study participants

	Sympathectomy group (*n*=40)	Sympathicotomy Group (*n*=40)	*P* value
Age (years)	21 (7–35)	20 (8–35)	0.488
Gender			
Male	18 (45%)	20 (50%)	0.654
Female	22 (55%)	20 (50%)	
BMI (kg/m2)	22.7 (18–27.9)	22.4 (18.2–27.9)	0.661
Disease duration (years)	6 (5–10)	7 (5–10)	0.695

BMI: body mass index.

Table 2 Operative data in both study groups

	Sympathectomy group (*n*=40)	Sympathicotomy Group (*n*=40)	*P* value
Method of sacrifice			
Hook	37 (92.5%)	35 (87.5%)	0.456
Scissor	3 (7.5%)	5 (12.5%)	
Operative time (min)	46 (30–60)	33 (20–45)	<0.001*

significant enough to cause postoperative discomfort or stress to patients. After cardiothoracic consultation, all of these cases were managed conservatively by high-flow oxygen, and there was no need for intercostal chest tube insertion. Post-sympathectomy intercostal neuralgia was reported by 10% and 7.5% of patients in the sympathectomy and sympathicotomy groups, respectively (P=0.692). The duration of hospitalization ranged between 1 and 2 days in both groups, while the median time till returning to normal daily activities was 8 and 7 days in the sympathectomy and sympathicotomy groups, respectively (Table 3).

Compensatory hyperhidrosis was reported in 65% of sympathectomy cases versus 77.5% of sympathicotomy cases, which was comparable in the statistical analysis (P=0.217). The abdomen and back were the most affected regions, and the majority of patients had mild to moderate symptoms. Regarding the duration of that problem, most cases were temporary (76.9% and 77.4% of sympathectomy and sympathicotomy cases, respectively), whereas the remaining patients still had that problem at the last follow-up visit (Table 4).

Both approaches were associated with a significant decline in the severity of hyperhidrosis, indicating the efficacy of both procedures in the improvement of patient symptoms, and that was evident in the three affected regions. However, the plantar region showed less improvement compared with the palmar and axillary regions (Table 5). No patients developed a recurrence of their hyperhidrosis manifestations after its improvement during the follow-up period.

Both groups showed a significant improvement in their QOL, manifested in the decline in the Keller questionnaire (P<0.001), and that decline was statistically comparable between the two groups (Table 6).

Both groups expressed no significant difference regarding patient satisfaction with the procedure outcomes (P=0.952). Only patients with permanent compensatory hyperhidrosis reported poor satisfaction in both groups (Table 7).

Discussion

We conducted the current trial to elucidate if the method of sympathetic chain interruption could affect the incidence of compensatory hyperhidrosis and other outcomes in patients with palmar–axillary–plantar hyperhidrosis. The literature is poor with studies comparing the previous two approaches in patients with the three-region disease,

Table 3 Postoperative data and complications in both groups

	Sympathectomy group (n=40)	Sympathicotomy Group (n=40)	P value
Pain score	5 (4–7)	4 (4–7)	0.083
Hemothorax	0 (0%)	0 (0%)	_____
Pneumothorax	2 (5%)	2 (5%)	1
Surgical emphysema	5 (12.5%)	4 (10%)	0.723
Horner syndrome	0 (0%)	0 (0%)	_____
Intercostal neuralgia	4 (10%)	3 (7.5%)	0.692
Hospital stay (day)	1 (1–2)	1 (1–2)	0.998
Return to daily activity (day)	8 (6–9)	7 (6–9)	0.054

Table 4 Compensatory hyperhidrosis in both study groups

	Sympathectomy group	Sympathicotomy group	P value
Incidence	26 (65%)	31 (77.5%)	0.217
Site			
Abdomen and backs	14 (53.8%)	20 (64.5%)	0.627
Abdomen	5 (19.2%)	5 (16.1%)	
Back	4 (15.4%)	5 (16.1%)	
Gluteal region	3 (11.5%)	1 (3.2%)	
Severity			
Mild	20 (76.9%)	25 (80.6%)	0.943
Moderate	4 (15.4%)	4 (12.9%)	
Severe	2 (7.7%)	2 (6.5%)	
Duration			
Temporary	20 (76.9%)	24 (77.4%)	0.965
Permanent	6 (23.1%)	7 (22.6%)	

Table 5 Changes in the severity of hyperhidrosis in both groups

	Sympathectomy group (*n*=40)	Sympathicotomy Group (*n*=40)	*P* value
The palmar region			
Preoperative	8 (7–10)	8 (7–10)	0.817
Postoperative	0 (0–2)	0 (0–2)	0.290
P value	<0.001*	<0.001*	
The axillary region			
Preoperative	9 (7–10)	8 (7–10)	0.466
Postoperative	1 (0–2)	0 (0–2)	0.519
P value	<0.001*	<0.001*	
The plantar region			
Preoperative	7 (7–10)	7 (7–10)	0.675
Postoperative	3 (2–5)	3 (2–5)	0.662
P value	0.009*	0.011*	

Table 6 QOL changes in both study groups according to the Keller questionnaire

	Sympathectomy group (*n*=40)	Sympathicotomy Group (*n*=40)	*P* value
Preoperative	8 (6–10)	8 (6–10)	0.265
Postoperative	1 (0–4)	2 (0–4)	0.450
P value	<0.001*	<0.001*	

Table 7 Patient satisfaction in both study groups

	Sympathectomy group (*n*=40)	Sympathicotomy Group (*n*=40)	*P* value
Patient satisfaction			
Poor	6 (15%)	7 (17.5%)	0.952
Fair	6 (15%)	8 (20%)	
Good	6 (15%)	6 (15%)	
Very good	7 (17.5%)	7 (17.5%)	
Excellent	15 (37.5%)	12 (30%)	

as most existing studies included patients with hyperhidrosis affecting one or two anatomical regions. That poses an advantage in favor of our research.

According to our preoperative findings, the reader should conclude that we used a proper randomization technique, as most variables were statistically comparable between the two groups. Consequently, that should decline any bias skewing our findings in favor of one group over the other.

Regarding our ablated levels, we decided to ablate T3-5 levels in patients in either group, as all our patients had combined palmar–axillary–plantar hyperhidrosis. This is in agreement with the concept published in the literature, which states that T3 ganglion ablation should be used for palmar symptoms, and T4 ganglion ablation should be used for axillary symptoms [24]. In addition, other authors reported that T4-5 interruption is also an effective option for combined palmar and plantar hyperhidrosis or combined palmar–axillary–plantar disease [11,25]. That is why we combined the three levels to achieve better disease control in the three affected regions.

We noted a significantly longer operative time in the sympathectomy group, and that could be secondary to the extra time needed for the additional third port along with dissection and excision of the sympathetic chain segment. Aydemir and associates confirmed our findings, as the sympathectomy procedure had an average time of 50 min (range, 30–90) compared with an average of 36 min for the sympathicotomy approach (range, 15–70) [24].

The recorded postoperative pain scores did not differ between our two approaches, and that was also confirmed by Mohebbi *et al.*, who reported comparable pain scores during the early and late postoperative periods [26].

In the current trial, we noted a significant decline in the severity of hyperhidrosis manifestations in the three anatomical regions compared with the preoperative values in both groups. Subsequently, there was a

significant improvement in the patient QOL in both groups. Another study reported that both techniques were equally effective in the relief of hyperhidrosis-related symptoms, which were noted in the palms of all patients after T3 interruption [24]. In addition, Cheng and colleagues reported that resolution of palmar hyperhidrosis was achieved in 87.5% and 87.6% of patients in sympathectomy and sympathicotomy groups, respectively, which was statistically comparable [12]. Inan *et al.* also reported the comparable efficacy of thoracic sympathetic block procedures, whatever the adopted approach [27].

The less improvement in the plantar region in our study could be explained by the fact that sweat glands in that region are predominantly supplied by the lumbar sympathetic chain.

No patients developed recurrence of their manifestations after its improvement in our study. Although we followed our patients for only 6 months after the operation, surgical failure or recurrence commonly occurs during the initial 6 months after the operation [28,29]. Similar to our findings, Inan *et al.* reported a 0% recurrence rate after the same two approaches over a longer follow-up period (36 months) [27].

In the current study, intercostal neuralgia was reported by 10% and 7.5% of sympathectomy and sympathicotomy patients, respectively. As that condition is caused by intercostal nerve damage [30], it is expected to have a slightly higher incidence in patients who have had more thoracoscopic ports. Likewise, other authors reported the incidence of the same complication in 6.67% and 4.25% of sympathectomy and sympathicotomy cases, respectively [24].

In our study, the sympathicotomy group experienced a slightly higher incidence of compensatory hyperhidrosis (77.5% vs. 65% in the sympathectomy group). Our incidence in both groups lies within the range reported in the literature, which ranges between 50% and 90% [14,31–33]. It is believed that excessive manipulation of the sympathetic chain with either sympathectomy or sympathicotomy results in ganglion damage and reflex hyperhidrosis [34].

Similar to our findings, Lin *et al.* reported an incidence of 84.8% for the same complication in association with sympathicotomy, which was higher than its rate with sympathectomy (67.8%) [35]. Moreover, Mohebbi *et al.* reported a significant rise in the same complication in the sympathicotomy approach (90% vs. 73.3% for sympathectomy – $P<0.001$) [26].

Another study reported no significant impact of the method of interruption on the development of that complication that was encountered in 89% of sympathectomy patients compared with 85.11% of sympathicotomy cases. Although that study reported a slightly higher incidence of compensatory sweating in the sympathectomy group, intolerable manifestations were more common with sympathicotomy (8.51% vs. 6.67% in the other group) [24]. Cheng *et al.* also reported a higher incidence of the same complication in association with sympathectomy (77.1% vs. 72.2% with sympathicotomy) with the absence of a significant difference in the statistical analysis ($P>0.05$) [12].

Some hypotheses have been reported to explain lower compensatory sweating with sympathicotomy. The approach entails less manipulation of the sympathetic ganglia, leading to a smaller area of skin dryness, which is associated with less severe reflex hyperhidrosis [36]. In addition, resection of any part of the sympathetic chain could induce the death of certain spinal cord neurons, resulting in increased sympathetic tone [37].

One could see some heterogenicity among studies regarding the incidence of compensatory hyperhidrosis. That could be explained by different levels among studies along with different assessment methods [18,38].

We did not detect any significant differences between reported patient satisfaction in our two groups. Another long-term study that followed the patients for 5 years also reported no significant difference regarding patient satisfaction, whatever the type of the operation [12].

In our study, the patients who reported poor satisfaction had permanent compensatory hyperhidrosis, which confirms the negative impact of that complication on patient outcomes [39,40].

Our trial handles a rare surgical topic that is rarely discussed in the literature. Nonetheless, it has some limitations manifested in the small sample size and lack of long-term follow-up. More studies should be performed to cover these limitations. Also, we recommend using the valvular technique in port placement or doing adequate compression after

deflation and port removal as a method to decrease the incidence of postoperative surgical emphysema.

Conclusion

Based on the preceding findings, both sympathectomy and sympathicotomy had comparable outcomes in patients with palmar–axillary–plantar hyperhidrosis, manifested in comparable decreased sweating severity, incidence of compensatory hyperhidrosis, quality of life, and patient satisfaction. The surgeon is recommended to perform the approach that he is experienced with until reaching a global consensus delineating the best interruption technique.

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Conflict of interest

There are no conflicts of interest.

References

1 Doolittle J, Walker P, Mills T, Thurston J. Hyperhidrosis: an update on prevalence and severity in the United States. Arch Dermatol Res 2016; 308:743–749. https://doi.org/10.1007/s00403-016-1697-9.

2 Ricchetti-Masterson K, Symons JM, Aldridge M, Patel A, Maskell J, Logie J, *et al.* Epidemiology of hyperhidrosis in 2 population-based health care databases. J Am Acad Dermatol 2018; 78:358–362. https://doi.org/10.1016/j.jaad.2017.10.004.

3 Sammons JE, Khachemoune A. Axillary hyperhidrosis: a focused review. J Dermatolog Treat 2017; 28:582–590. https://doi.org/10.1080/09546634.2017.1309347.

4 Shabaik AHA, Shaheen MA, Soltan MY. Efficacy of photodynamic therapy for treatment of primary palmar hyperhidrosis. Dermatol Ther 2021; 34: e14659. https://doi.org/10.1111/dth.14659.

5 Lin JB, Lin NL, Li X, Kang MQ. Antagonist of Chrna1 prevents the pathogenesis of primary focal hyperhidrosis. Ann Clin Transl Neurol 2022; 9:786–794. https://doi.org/10.1002/acn3.51558.

6 Hornberger J, Grimes K, Naumann M, Glaser DA, Lowe NJ, Naver H, *et al.* Recognition, diagnosis, and treatment of primary focal hyperhidrosis. J Am Acad Dermatol 2004; 51:274–286. https://doi.org/10.1016/j.jaad.2003.12.029.

7 Parashar K, Adlam T, Potts G. The Impact of Hyperhidrosis on Quality of Life: A Review of the Literature. Am J Clin Dermatol 2023; 24:187–198. https://doi.org/10.1007/s40257-022- 00743-7.

8 Nawrocki S, Cha J. The etiology, diagnosis, and management of hyperhidrosis: A comprehensive review: Therapeutic options. J Am Acad Dermatol 2019; 81:669–680. https://doi.org/10.1016/j.jaad.2018.11.066.

9 Gregoriou S, Sidiropoulou P, Kontochristopoulos G, Rigopoulos D. Management Strategies Of Palmar Hyperhidrosis: Challenges And Solutions. Clin Cosmet Investig Dermatol 2019; 12:733–744. https://doi.org/10.2147/ccid. S210973.

10 Liu V, Farshchian M, Potts GA. Management of primary focal hyperhidrosis: an algorithmic approach. J Drugs Dermatol 2021; 20:523–528. https://doi.org/10.36849/jdd.5774.

11 Cerfolio RJ, De Campos JR, Bryant AS, Connery CP, Miller DL, DeCamp MM, *et al.* The Society of Thoracic Surgeons expert consensus for the surgical treatment of hyperhidrosis. Ann Thorac Surg. 2011; 91 (5):1642–1648. https://doi.org/10.1016/j.athoracsur.2011.01.105.

12 Cheng A, Johnsen H, Chang MY. Patient satisfaction after thoracoscopic sympathectomy for palmar hyperhidrosis: do method and level matter? Perm J 2015; 19:29–31. https://doi.org/10.7812/tpp/ 15-040.

13 Kuijpers M, van Zanden JE, Harms PW, Mungroop HE, Mariani MA, Klinkenberg TJ, *et al.* Minimally invasive sympathicotomy for palmar hyperhidrosis and facial blushing: current status and the hyperhidrosis expert center approach. J Clin Med 2022; 11:786. https://doi.org/10.3390/jcm11030786.

14 Raveglia F, Orlandi R, Guttadauro A, Cioffi U, Cardillo G, Cioffi G, *et al.* How to prevent, reduce, and treat severe post sympathetic chain compensatory hyperhidrosis: 2021 state of the Art. Front Surg 2021; 8:814916. https://doi.org/10.3389/fsurg.2021.814916.

15 Weksler B Is there light at the end of the tunnel for patients with severe compensatory hyperhidrosis? J Thorac Cardiovasc Surg 2017; 154:e117. https://doi.org/10.1016/j.jtcvs.2017.08.054.

16 Wolosker N, Milanez de Campos JR, Fukuda JM. Management of compensatory sweating after sympathetic surgery. Thorac Surg Clin 2016; 26:445–451. https://doi.org/10.1016/j.thorsurg.2016.06.009.

17 Du X, Zhu X, Wang T, Hu X, Lin P, Teng Y, *et al.* Compensatory hyperhidrosis after different surgeries at the same sympathetic levels: a meta-analysis. Ann Transl Med 2018; 6:203. https://doi.org/10.21037/atm.2018.05.24.

18 Elalfy K, Emile S, Elfeki H, Elmetwally A, Farag M, Gado W. sequential extended thoracoscopic sympathicotomy for palmo-axillo-plantar Hyperhidrosis. Ann Thorac Surg 2017; 104:1200–1207. https://doi.org/10.1016/j.athoracsur.2017.04.035.

19 Keller SM, Bello R, Vibert B, Swergold G, Burk R. Diagnosis of palmar hyperhidrosis via questionnaire without physical examination. Clin Auton Res 2009; 19:175–181. https://doi.org/10.1007/s10286-009- 0006-5.

20 Haefeli M, Elfering A. Pain assessment. Eur Spine J 2006; 15 Suppl 1 (Suppl 1):S17–S24. https://doi.org/10.1007/s00586-005-1044-x.

21 Weng W, Liu Y, Li J, Jiang G, Liu J, Wang J. A long-term evaluation of postoperative moist hands after R4/R4+5 sympathectomy for primary palmar hyperhidrosis. J Thorac Dis 2018; 10:1532–1537. https://doi.org/10.21037/jtd.2018.02.07.

22 Di Palo MT. Rating satisfaction research: is it poor, fair, good, very good, or excellent? Arthritis Care Res 1997; 10:422–430. https://doi.org/10.1002/art.1790100610.

23 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. https://doi.org/10.1590/s 1806-37132008001100013.

24 Aydemir B, Imamoglu O, Okay T, Celik M. Sympathectomy versus Sympathicotomy in palmar hyperhidrosis comparing T3 ablation. Thorac Cardiovasc Surg 2015; 63:715–719. https://doi.org/10.1055/s- 0034-1384666.

25 Vannucci F, Araújo JA. Thoracic sympathectomy for hyperhidrosis: from surgical indications to clinical results. J Thorac Dis 2017; 9(Suppl 3): S178–s92. https://doi.org/10.21037/jtd.2017.04.04.

26 Mohebbi HA, Mehrvarz S, Manoochehry S. Thoracoscopic Sympathicotomy vs Sympathectomy in primary hyperhidrosis. Trauma Mon 2012; 17:291–295. https://doi.org/10.5812/traumamon.6335.

27 Inan K, Goksel OS, Uçak A, Temizkan V, Karaca K, Ugur M, *et al.* Thoracic endoscopic surgery for hyperhidrosis: comparison of different techniques. Thorac Cardiovasc Surg 2008; 56:210–213. https://doi.org/10.1055/s-2007-989327.

28 Cohen Z, Levi I, Pinsk I, Mares AJ. Thoracoscopic upper thoracic sympathectomy for primary palmar hyperhidrosis-the combined paediatric, adolescents and adult experience. Eur J Surg Suppl 1998; 580:5–8. https://doi.org/10.1080/11024159850191049.

29 Jeganathan R, Jordan S, Jones M, Grant S, Diamond O, McManus K, *et al.* Bilateral thoracoscopic sympathectomy: results and long-term follow-up. Interact Cardiovasc Thorac Surg 2008; 7:67–70. https://doi.org/10.1510/icvts.2007.162479.

30 Homma T, Doki Y, Yamamoto Y, Ojima T, Shimada Y, Kitamura N, *et al.* Risk factors of neuropathic pain after thoracic surgery. J Thorac Dis 2018; 10:2898–2907. https://doi.org/10.21037/jtd.2018.05.25.

31 Schick CH. Pathophysiology of hyperhidrosis. Thorac Surg Clin 2016; 26:389–393. https://doi.org/10.1016/j.thorsurg.2016.06.002.

32 Wolosker N, Leiderman DBD, de Campos JRM, Kauffman P, Tedde ML, Yazbek G, *et al.* Number of preoperative hyperhidrosis sites does not affect the sympathectomy postoperative results and compensatory hyperhidrosis occurrence. Thorac Cardiovasc Surg 2019; 67:407–414. https://doi.org/10.1055/s- 0038-1667317.

33 Joo S, Lee GD, Haam S, Lee S. Comparisons of the clinical outcomes of thoracoscopic sympathetic surgery for palmar hyperhidrosis: R4 sympathicotomy versus R4 sympathetic clipping versus R3 sympathetic

clipping. J Thorac Dis 2016; 8:934–941. https://doi.org/10.21037/jtd.2016.03.57.

34 Bonjer HJ, Hamming JF, du Bois N, van Urk H. Advantages of limited thoracoscopic sympathectomy. Surg Endosc 1996; 10:721–723. https://doi.org/10.1007/bf00193043.

35 Lin CL, Yen CP, Howng SL. The long-term results of upper dorsal sympathetic ganglionectomy and endoscopic thoracic sympathectomy for palmar hyperhidrosis. Surg Today 1999; 29:209–213. https://doi.org/10.1007/bf02483008.

36 O'Riordain DS, Maher M, Waldron DJ, O'Donovan B, Brady MP. Limiting the anatomic extent of upper thoracic sympathectomy for primary palmar hyperhidrosis. Surg Gynecol Obstet 1993; 176:151–154

37 Atkinson JL, Fealey RD. Sympathotomy instead of sympathectomy for palmar hyperhidrosis: minimizing postoperative compensatory hyperhidrosis. Mayo Clin Proc 2003; 78:167–172. https://doi.org/10.4065/78.2.167.

38 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 3-5. https://doi.org/10.1097/00006123- 199707000-00023.

39 Ruan GJ, Thuppal S, Sawyer JD, Seadler B, Markwell S, Hazelrigg SR. Compensatory Hyperhidrosis and quality of life post sympathectomy for palmar hyperhidrosis. Am Surg 2019; 85:438–440

40 Vasconcelos CFM, Aguiar WS, Tavares RM, Barbosa A, Cordeiro GG, Oliveira FSC, *et al.* Bilateral R5-R8 sympathectomy for compensatory hyperhidrosis: complications and patient satisfaction. Rev Col Bras Cir 2020; 47:e20202398. https://doi.org/10.1590/0100-6991e-2020 2398.