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Outcomes of Single-Level and Multi-Level Thoracoscopic Sympathectomy in Primary Axillary Hyperhidrosis: A Multicenter Retrospective Analysis

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Abstract:

Objective: Primary axillary hyperhidrosis is associated with substantial impairment in quality of life, and endoscopic thoracic sympathectomy (ETS) provides definitive treatment in refractory cases. However, the optimal level of sympathetic interruption remains controversial, and evidence directly comparing different surgical levels in axillary disease is limited. This study aimed to compare surgical outcomes among three sympathectomy levels in patients with primary axillary hyperhidrosis.

Methods: This retrospective multicenter study included 83 patients who underwent bilateral clip-based thoracoscopic sympathectomy for primary axillary hyperhidrosis between 2009 and 2023. Patients were stratified into three groups: single-level R3 (n=24), single-level R4 (n=35), and multi-level R2–R4 (n=24). The primary outcome was compensatory hyperhidrosis. Secondary outcomes included complete remission, recurrence, postoperative complications, and patient satisfaction. Factors associated with outcomes were evaluated using univariate and multivariate logistic regression analyses.

Results: Compensatory hyperhidrosis occurred in 83.3% of patients in the R2–R4 group, compared with 75.0% in the R3 group and 54.3% in the R4 group (P=0.045). Complete remission rates were comparable among groups (54.2%, 41.7%, and 34.3%, respectively; P=0.452). In multivariate analysis, R4 sympathectomy was associated with significantly lower odds ratio (OR) of compensatory hyperhidrosis compared with R2–R4 (OR: 0.25, 95% CI: 0.06–0.97; P=0.044). Recurrence rates did not differ significantly among groups (20.8%, 25.7%, and 12.5%, respectively; P=0.466). Recurrence was the only independent predictor of patient dissatisfaction (OR: 0.12, 95% CI: 0.03–0.44; P=0.001).

Conclusion: Single-level R4 sympathectomy appears to provide a favorable balance between treatment efficacy and side-effect profile in primary axillary hyperhidrosis. Multi-level approaches were not associated with improved clinical outcomes but were linked to higher rates of compensatory hyperhidrosis. These findings should be interpreted with caution.

Keywords: Axillary Hyperhidrosis, Endoscopic Thoracic Sympathectomy, Compensatory Hyperhidrosis, Sympathectomy Level

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Primary hyperhidrosis is a chronic autonomic disorder characterized by excessive sweating beyond physiological thermoregulatory requirements and affects approximately 1–3% of the general population [1, 2]. The axillary region is among the most commonly affected sites, accounting for approximately 50% of primary hyperhidrosis cases either as an isolated condition or in combination with palmar and plantar involvement [3, 4]. Primary axillary hyperhidrosis typically manifests during adolescence or early adulthood and is associated with significant impairment in daily activities, occupational performance, and social interactions, with up to 90% of patients reporting moderate to severe quality of life deterioration comparable to that observed in chronic debilitating diseases [5, 6].

Conservative treatment modalities—including topical antiperspirants, systemic anticholinergic agents, and botulinum toxin injections—may provide symptomatic relief; however, their effectiveness is often temporary and limited by recurrence, treatment burden, or adverse effects [7, 8]. Consequently, endoscopic thoracic sympathectomy (ETS) has become an established definitive treatment option for patients with refractory axillary hyperhidrosis, offering high rates of durable symptom control [9–11]. Despite its efficacy, compensatory hyperhidrosis (CH)—defined as new or increased sweating in previously unaffected body regions—remains the most frequent postoperative complication, occurring in 30–90% of patients depending on surgical extent and level, and represents the primary determinant of long-term patient dissatisfaction [12–14].

Despite the widespread use of endoscopic thoracic sympathectomy for axillary hyperhidrosis, the optimal level of sympathetic interruption remains poorly defined. Most available evidence is derived from studies focusing predominantly on palmar hyperhidrosis, and data specifically addressing axillary disease are limited and inconsistent [10, 11, 15, 16]. In particular, direct comparisons between different levels of sympathectomy within a homogeneous axillary hyperhidrosis population are scarce.

Therefore, the present multicenter study aims to address this gap by directly comparing surgical outcomes across three commonly used sympathectomy levels (labeled by rib number) (R3, R4, and R2–R4) in patients with primary axillary hyperhidrosis. By focusing exclusively on axillary disease and evaluating both efficacy and patient-centered outcomes, this study seeks to provide clinically relevant evidence to guide the selection of the optimal surgical level.

METHODS

This retrospective multicenter comparative cohort study evaluated surgical outcomes in patients with primary axillary hyperhidrosis who underwent bilateral endoscopic thoracic sympathectomy (ETS) between May 2009 and July 2023 at two high-volume thoracic surgery centers. The primary outcome was the incidence of compensatory hyperhidrosis. Secondary outcomes included axillary symptom control, recurrence, postoperative complications, and patient satisfaction.

From an initial cohort of 341 patients treated surgically for hyperhidrosis during the study period, 258 were excluded based on predefined criteria: isolated non-axillary hyperhidrosis (palmar-only or craniofacial disease, n=176), use of electrocautery or sympathetic chain resection rather than standardized clip-based sympathetic blockade (n=49), and incomplete surgical or follow-up records (n=33). The final study population comprised 83 patients who met all inclusion criteria.

Inclusion criteria were: (1) age ≥16 years; (2) primary axillary hyperhidrosis meeting established diagnostic criteria; (3) bilateral ETS performed using a standardized clip-based technique; and (4) minimum clinical follow-up of 12 months. Exclusion criteria were: (1) isolated non-axillary hyperhidrosis (palmar-only or craniofacial); (2) sympathectomy involving electrocautery or sympathetic chain resection; and (3) incomplete surgical or follow-up data.

Diagnostic Criteria

Primary axillary hyperhidrosis was diagnosed clinically based on the presence of excessive bilateral axillary sweating persisting for at least 6 months, in the absence of an identifiable secondary cause. Symptoms were required to be clinically significant and to negatively affect daily, social, or occupational activities, consistent with previously published reports on axillary hyperhidrosis.

Ethical Considerations

The study was approved by the Bursa Uludağ University Health Research Ethics Committee (Approval No. 2026/60/3-4) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants. All patients underwent standardized diagnostic evaluation, preoperative assessment, and operative protocols across both centers.

Surgical Level Selection and Institutional Practice

The selection of sympathetic interruption level was determined by center-specific institutional protocols and was not individualized based on patient characteristics such as age, body mass index, or symptom severity, potentially introducing selection bias. Both centers employed standardized rib-oriented nomenclature for anatomical localization.

At Center 1, a single-level sympathectomy approach was routinely applied, targeting either the third rib (R3) or fourth rib (R4) level. Institutional practice evolved during the study period: R3 sympathectomy was predominantly performed between 2009 and 2018, while R4 sympathectomy became the preferred approach from 2019 onward. This shift reflected an institutional strategy to minimize compensatory hyperhidrosis while maintaining effective axillary symptom control.

In contrast, Center 2 consistently employed a multi-level sympathectomy strategy involving interruption from the second to fourth rib levels (R2–R4) throughout the entire study period. This approach remained unchanged regardless of temporal trends or individual patient factors.

Preoperative Evaluation and Study Groups

Baseline demographic and clinical variables recorded included age, sex, body mass index (BMI), smoking status, family history of hyperhidrosis, and preoperative symptom severity. Symptom severity was assessed using the Hyperhidrosis Disease Severity Scale (HDSS) [12], a validated 4-point patient-reported outcome measure. HDSS scores of 3 or 4 indicate severe hyperhidrosis with a significant impact on daily activities and are generally considered an indication for surgical treatment, whereas scores of 1 or 2 reflect mild to moderate symptoms. All patients included in the present study had baseline HDSS scores of 3 or 4, consistent with severe axillary hyperhidrosis.

Patients were categorized into three study groups according to the level of bilaterally symmetrical sympathetic interruption, using the rib-oriented nomenclature. Group allocation was based on the institutional surgical protocol in effect at the time of surgery. The study groups were defined as follows:

•Group 1 (R3): Single-level sympathectomy at the third rib level (n=24)

•Group 2 (R4): Single-level sympathectomy at the fourth rib level (n=35)

•Group 3 (R2-R4): Multi-level sympathectomy involving interruption from R2 to R4 (n=24)

All procedures were performed bilaterally with symmetrical interruption levels, and no patient-specific clinical factors were used to individualize the level of sympathetic interruption.

Operative Technique

All operations were performed by experienced thoracic surgeons under general anesthesia with single-lung ventilation achieved using a double-lumen endotracheal tube. Patients were positioned semi-seated (Fowler position) with both arms abducted to facilitate bilateral thoracoscopic access. A standardized two-port approach was employed in all cases: a 5-mm camera port was placed at the anterior axillary line in the fifth intercostal space for a 30° thoracoscope, while a 5-mm working port was positioned along the mid-axillary line at the third or fourth intercostal space, depending on the planned interruption level.

After entering the thoracic cavity, the parietal pleura overlying the sympathetic chain was incised using electrocautery to expose the target anatomy. Sympathetic blockade was accomplished by applying a single 5-mm titanium clip at the predetermined rib level for single-level procedures (R3 or R4), or by placing clips sequentially at each level for multi-level sympathectomy (R2, R3, and R4). To ensure complete denervation, accessory nerve fibers (Kuntz fibers) and rami communicantes were divided over a 2–3 cm segment adjacent to the clipped level. The sympathetic chain itself was preserved intact, with no transection, cauterization, or resection performed.

Upon completion of the procedure, residual pneumothorax was evacuated under direct visualization prior to port removal. The contralateral side was then addressed using identical technique during the same anesthetic session. Surgical levels were documented intraoperatively and confirmed by chest radiography on the first postoperative day. Patients were typically discharged within 24 hours in the absence of complications.

Follow-up Protocol and Outcome Assessment

Patients were evaluated postoperatively at 6 and 12 months, followed by annual outpatient visits thereafter. In addition to scheduled follow-up, patients were instructed to contact the outpatient clinic if they experienced new or worsening symptoms between visits. Follow-up data were collected using a standardized assessment protocol applied consistently across participating centers. The mean duration of follow-up was 88.89 months (range, 12–172 months). Follow-up duration varied between groups due to differences in institutional practice and temporal changes in surgical strategy.

The primary outcome was compensatory hyperhidrosis (CH) incidence. Secondary outcomes included axillary symptom control, recurrence, postoperative complications, and patient satisfaction. Axillary sweating control was assessed based on patient self-report and categorized as complete resolution, partial improvement (≥50% reduction), or no meaningful improvement. Compensatory hyperhidrosis was defined as new or increased sweating in body regions not affected preoperatively and was graded according to the Society of Thoracic Surgeons classification as mild (noticeable but not bothersome), moderate (bothersome and occasionally requiring clothing changes), or severe (intolerable and interfering with daily activities). Recurrence was defined as the reappearance of clinically significant axillary sweating after an initial postoperative improvement.

Patient satisfaction was assessed at the final follow-up visit as a binary outcome (satisfied vs. dissatisfied), including patients' stated willingness to undergo the same surgical procedure again under similar circumstances. Postoperative complications were systematically documented, including pneumothorax, intercostal neuralgia, Horner's syndrome, and wound infection. Hospital length of stay and smoking status (classified as current, former, or never smoker) were recorded at each visit.

Statistical Analysis

All statistical analyses were performed using

TABLE 1. Demographic and Baseline Clinical Characteristics of Patients Undergoing R3, R4, Or R2–R4 Sympathectomy.

Variable	Group 1 (R3) (n=24)	Group 2 (R4) (n=35)	Group 3 (R2–R4) (n=24)	P-value
Sex				0.345
Female	16 (66.7%)	20 (57.1%)	11 (45.8%)	
Male	8 (33.3%)	15 (42.9%)	13 (54.2%)	
Age (years)	22.54±7.5	25.23±5.79	26.13±7.75	0.044
BMI (kg/m²)	22.42±3.12	23.15±3.57	23.97±3.27	0.329
Smoking history	10 (41.7%)	13 (37.1%)	13 (54.2%)	0.423
Positive family history	12 (50%)	9 (25.7%)	11 (45.8%)	0.117
HDSS	4:18 (75%) 3:5 (20.8%) 2:1 (4.2%)	4:28 (80%) 3:7 (20%)	4:22 (91.7%) 3:2 (8.3%)	0.289
Follow-up time (months)	86.5 (13-172)	109 (28-121)	58 (12-97)	

Data are shown as mean±standard deviation or n (%) or median (interquartile=IQR) where appropriate. BMI, body mass index; HDSS, hyperhidrosis disease severity scale.

SPSS software version 28.0 (IBM Corp., Armonk, NY, USA). Primary comparisons were conducted among the three surgical groups defined by the level of sympathetic interruption. Continuous variables were summarized as mean±standard deviation or median with interquartile range (IQR), depending on distribution. Categorical variables were presented as frequencies and percentages. Group comparisons for continuous variables were performed using one-way analysis of variance (ANOVA) for normally distributed data or the Kruskal–Wallis test for non-normally distributed data. Categorical variables were compared using the chi-square test or Fisher's exact test when expected cell counts were less than 5. Univariate logistic regression analyses were conducted to identify factors associated with the primary outcome (compensatory hyperhidrosis) and secondary outcomes (patient satisfaction and recurrence). Variables with P<0.20 in univariate analysis were considered for inclusion in multivariate logistic regression models. Covariates evaluated for compensatory hyperhidrosis included age, body mass index (BMI), smoking status, preoperative HDSS score, postoperative complications, and surgical level. For patient satisfaction, recurrence status was additionally evaluated as a covariate. Surgical level was analyzed using single-level sympathectomy as the reference category. Because the choice of surgical level was entirely determined by center-specific institutional protocols, adjustment for center was not performed, as this would introduce substantial collinearity between treatment group and center, potentially compromising model stability and interpretability. Results were reported as odds ratios (ORs) with 95% confidence intervals (CIs). A two-sided P-value <0.05 was considered statistically significant.

RESULTS

A total of 83 patients underwent bilateral thoracoscopic sympathectomy for primary axillary hyperhidrosis and were stratified into three groups: R3 (n=24), R4 (n=35), and R2–R4 (n=24). Baseline characteristics were generally well-balanced across groups (Table 1). The cohort had a mean age of 24.7 years (range 16–55), with 56.6% female patients and a mean BMI of 23.1 kg/m². Nearly all patients (98.8%) presented with severe symptoms (HDSS 3–4), indicating appropriate surgical candidate selection. Median follow-up duration was longer in the R3 and R4 groups (86.5 and 109 months, respectively) compared with the R2–R4 group (58 months), reflecting differences in institutional protocols and temporal changes in surgical strategy.

All patients achieved immediate intraoperative control of axillary sweating, with no operative mortality or conversion to open surgery. Postoperative length of stay and complication rates were comparable across

TABLE 2. Surgical Outcomes and Postoperative Results of Patients Undergoing Endoscopic Thoracic Sympathectomy

Observed indicators	Group 1 (R3) (n=24)	Group 2 (R4) (n=35)	Group 3 (R2-4) (n=24)	P-value	G1 vs G2	G1 vs. G3	G2 vs. G3
Symptom relief, n (%)				0.452	0.552	0.524	0.215
Complete	10 (41.7%)	12 (34.3%)	13 (54.2%)				
Partial	13 (54.2%)	21 (60%)	9 (37.5%)				
Unchanged	1 (4.2%)	2 (5.7%)	2 (8.3%)				
CH (ever developed), n (%)	18 (75%)	19 (54.3%)	20 (83.3%)	**0.045**	0.106	0.477	**0.021**
Mild	7 (29.2%)	4 (11.2%)	5 (20.8%)				
Moderate	6 (25%)	10 (28.6%)	10 (41.7%)				
Severe	5 (20.8%)	5 (14.3%)	6 (25%)				
Recurrence, n (%)	5 (20.8%)	9 (25.7%)	3 (12.5%)	0.466	0.665	0.215	0.439
Satisfied, n (%)	18 (75%)	27 (77.1%)	16 (66.7%)	0.657	0.849	0.525	0.374
Would undergo again? n (%)	17 (70.8%)	26(74.3%)	16 (66.7%)	0.817	0.77	0.755	0.526

Data are shown as n (%). CH, compensatory hyperhidrosis; G1, group 1; G2, group 2; G3, Group 3.
Statistically significant P-values are shown in bold.

groups (mean length of stay: 1.13, 1.06, and 1.33 days; respectively, P=0.588; complication rates: 8.3%, 5.8%, and 8.4%; respectively, P=0.902). The most common complication was pneumothorax (n=4), followed by wound infection (n=2) and intercostal neuralgia (n=1). Complete remission rates were comparable across groups (41.7%, 34.3%, and 54.2%, respectively; P=0.452). In contrast, compensatory hyperhidrosis differed significantly, occurring in 75.0%, 54.3%, and 83.3% of patients in Groups 1–3, respectively (P=0.045). Recurrence rates were similar among groups (20.8%, 25.7%, and 12.5%, respectively; P= 0.466), with six patients requiring reoperation.

Patient satisfaction was high (73.5%) and comparable across groups (75.0%, 77.1%, and 66.7%, respectively; P=0.657). Similarly, willingness to undergo the procedure again did not differ significantly among groups (70.8%, 74.3%, and 66.7%; p = 0.817). A detailed summary of postoperative outcomes and symptom control is provided in Table 2.

Factors Associated with Outcomes

Univariate and multivariate regression analyses are presented in Table 3. After adjustment, R4 demonstrated lower CH risk versus R2–R4 (OR: 0.25, P=0.044). Age predicted recurrence (OR: 1.08, P=0.046). Recurrence was the only independent predictor of dissatisfaction (OR: 0.12, P=0.001).

DISCUSSION

This study compared three sympathectomy levels in patients with primary axillary hyperhidrosis and found that multi-level R2–R4 sympathectomy was associated with higher rates of compensatory hyperhidrosis compared with single-level approaches. Compensatory hyperhidrosis occurred in 83.3% of patients in the R2–R4 group, compared with 75.0% in R3 and 54.3% in R4 (P=0.045), whereas complete remission rates did not differ significantly (54.2%, 41.7%, and 34.3%, respectively; P=0.452). In multivariate analysis, R4 sympathectomy was

TABLE 3. Factors Associated with Compensatory Hyperhidrosis, Recurrence, and Patient Satisfaction

Outcomes	Variable	OR	95% CI	P-value
CH (Univariate)	Smoking	3.70	1.30-10.59	**0.015**
	Surgical Level	-	-	0.053
	R3 vs. R2-4	0.60	0.15-2.47	0.480
	R4 vs. R2-4	0.24	0.07-0.84	**0.026**
CH (Multivariate)	Surgical level	-		**0.043**
	R4 vs. R2-4	0.25	0.06-0.97	**0.044**
	Smoking	2.89	0.87-9.60	0.083
Recurrence (Univariate)	Age (per year)	1.08	1.00-1.16	**0.046**
Satisfaction (Univariate)	Age (per year)	0.91	0.85-0.99	**0.020**
	BMI (per kg/m2)	0.8	0.74-1.00	**0.042**
	CH	0.15	0.03-0.72	**0.017**
	Recurrence	0.11	0.03-0.36	**<0.001**
Satisfaction (Multivariate)	Recurrence	0.12	0.03-0.44	**0.001**
	Age (per year)	0.93	0.85-1.01	0.094
	BMI (per kg/m2)	0.89	0.75-1.06	0.186
	CH	0.35	0.06-2.09	0.247

BMI, body mass index; CH, compensatory hyperhidrosis; CI, confidence interval; OR, odds ratio.
Statistically significant P-values are shown in bold.

associated with significantly lower odds of compensatory hyperhidrosis compared with R2–R4 (OR: 0.25, 95% CI: 0.06–0.97; P=0.044). From a clinical perspective, these findings suggest that increasing the extent of sympathectomy does not provide additional benefit in symptom control but may increase the risk of compensatory hyperhidrosis, highlighting the importance of balancing efficacy and adverse effects when selecting the surgical level.

Previous studies investigating optimal sympathetic interruption levels in hyperhidrosis have predominantly focused on palmar disease, and recommendations for axillary hyperhidrosis have largely been extrapolated from these cohorts. In palmar-dominant hyperhidrosis, limiting the extent of sympathectomy has been associated with lower rates of compensatory hyperhidrosis without compromising symptom control [10, 11]. However, evidence specifically addressing axillary hyperhidrosis remains limited and heterogeneous. While some authors have advocated multi-level interruption to enhance axillary dryness [9, 17], others have reported that more extensive sympathectomy does not result in improved clinical efficacy and is associated with higher rates of compensatory sweating[18]. In line with these reports, the present study found that multi-level sympathectomy (R2–R4) was not associated with improved axillary symptom control or reduced recurrence, but was accompanied by a higher incidence of compensatory hyperhidrosis. Taken together, these findings indicate that a limited, level-specific surgical approach may be sufficient for the treatment of axillary hyperhidrosis.

Recurrence after thoracoscopic sympathectomy represents a distinct clinical entity from compensatory hyperhidrosis and has been reported as a key factor influencing long-term patient satisfaction [9, 18]. In the present study, recurrence rates were comparable across surgical levels (20.8% in R3, 25.7% in R4, and 12.5% in R2–R4; P=0.466), indicating that the extent of sympathetic interruption did not significantly affect symptom recurrence. Age was the only variable associated with recurrence in univariate analysis (OR: 1.08 per year, P=0.046), whereas surgical level and other baseline characteristics were not. In multivariate analysis, recurrence was the sole independent predictor of patient dissatisfaction (OR: 0.12, 95% CI: 0.03–0.44; P=0.001), exceeding the impact of compensatory hyperhidrosis. Similar observations have been reported in previous series[17], highlighting that sustained symptom control is central to long-term satisfaction and should be prioritized alongside strategies to minimize compensatory sweating.

Strengths and Limitations

This study has several strengths that support the validity and clinical relevance of its findings. It includes a well-defined and relatively homogeneous cohort of patients with primary axillary hyperhidrosis, allowing a focused comparison between surgical levels. The use of a standardized clip-based thoracoscopic technique with rib-oriented classification reduces technical variability, while the multicenter design enhances external validity. In addition, the relatively long follow-up period enables the assessment of both early and late outcomes, including recurrence and patient satisfaction.

However, certain limitations should be considered when interpreting the results. The retrospective design and non-randomized, center-based selection of surgical level introduce potential selection bias, as treatment allocation was determined by institutional protocols rather than patient-specific factors. Furthermore, the limited number of outcome events may have reduced the statistical power of subgroup analyses. Differences in follow-up duration between groups may also have influenced the detection of late recurrence, although most events are known to occur in the early postoperative period. Therefore, these findings should be interpreted with caution and require confirmation in prospective, ideally randomized, studies.

CONCLUSION

Single-level thoracoscopic sympathectomy provides effective axillary symptom control, whereas multi-level interruption increases compensatory hyperhidrosis without improving recurrence or patient satisfaction. R4 sympathectomy offers the most favorable balance between efficacy and adverse effects in the surgical treatment of axillary hyperhidrosis.

Ethics Approval and Consent to Participate

This study was approved by the Bursa Uludağ University Health Research Ethics Committee. (Decision No: 2026/60/3-4; date: 04/02/2026). All procedures were conducted in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments. Informed consent was waived because of the retrospective nature of the study and the analysis used anonymous clinical data.

Data Availability

All data generated or analyzed during this study are included in this published article. The data that support the findings of this study are available on request from the corresponding author, upon reasonable request.

Authors' Contribution

Study Conception: EÖ, TE; Study Design: EÖ, HM, TE, CG; Supervision: EÖ, HM, CG; Funding: EÖ; Materials: EÖ, TE, HG; Data Collection and/or Processing: EÖ, HG, TE; Statistical Analysis and/or Data Interpretation: EÖ, HM; Literature Review: EÖ, HG, HM; Manuscript Preparation: EÖ; and Critical Review: EÖ, TE, HM, ASB, CG.

Conflict of Interest

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