

# Comparison of the Long-Term Results of R3 and R4 Sympathicotomy for Palmar Hyperhidrosis

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**Background:** Video-assisted thoracoscopic sympathectomy has been determined to be the best way to treat palmar hyperhidrosis. However, satisfaction with the surgical outcomes decreases with the onset of compensatory hyperhidrosis (CH) over time. The ideal level of sympathectomy is controversial. Therefore, we compared the long-term results of R3 and R4 sympathectomy. **Methods:** We retrospectively reviewed 186 patients who underwent video-assisted thoracoscopic sympathectomy between September 2001 and September 2015. We analyzed the long-term results with respect to hand sweating and CH, and the overall satisfaction in 186 patients. **Results:** With respect to hand sweating, significantly more patients complained of overly dry hands in the R3 group (25% versus 3.7%,  $p < 0.001$ ) and of mildly wet hands in the R4 group (2.9% versus 13.4%,  $p = 0.007$ ). There was a significantly increased occurrence rate of CH in the R3 group (97.1% versus 65.9%,  $p < 0.001$ ). The most frequent site of CH was the trunk area. The overall satisfaction was higher in the R4 group, but without significance (75% versus 85.4%,  $p = 0.082$ ). Significantly more patients reported being very satisfied in the R4 group (5.8% versus 22.0%,  $p = 0.001$ ). **Conclusion:** The R4 group had a higher rate of satisfaction than the R3 group with respect to hand sweating. CH and hand dryness were significantly less common in the R4 group than in the R3 group. The lower occurrence of hand dryness and CH resulted in a higher satisfaction rate in the R4 group.

**Key words:** 1. Hyperhidrosis  
2. Sympathectomy  
3. Sympathectomy

## Introduction

Primary hyperhidrosis is a disorder characterized by excessive sweating, usually in the hands and feet. The triggers are almost always emotional, although heat or exercise may also be triggers. Hyperhidrosis may be problematic psychologically and socially. Thoracoscopic sympathectomy has been considered to be the best way to cure hyperhidrosis [1]. However, long-term satisfaction decreases with the onset of compensatory hyperhidrosis (CH) and with hand dry-

ness over time. Controversies remain regarding the specific level of the sympathetic intervention. The surgical interventions for hyperhidrosis have been modified from the T2-T4 sympathectomy, T2-T3 sympathectomy, T2-T3 sympathectomy, and T4 sympathectomy techniques. These modifications were made to minimize the side effects of surgical interventions, particularly CH. We compared R3 and R4 sympathectomy to investigate which level had superior outcomes with respect to the condition of the hand, as indicated by the incidence of fewer side ef-

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fects after surgery. We analyzed the long-term results with respect to hand sweating and CH, and the overall satisfaction in 186 patients who underwent R3 or R4 sympathectomy between September 2001 and September 2015.

## Methods

A total of 228 patients underwent video-assisted thoracoscopic sympathectomy between September 2001 and September 2015. We collected data from 186 of these patients by using a telephone questionnaire and performed a retrospective review. We verbally explained that a questionnaire would be used in this study and received the patients' verbal consent over the telephone. More than 1 year had passed from the date of surgery to the time of the survey in all the cases. On the basis of clinical experience, we believe that in most cases, CH or its recurrence does not appear within 1 month of surgery, and long-term results are defined as results obtained more than 1 year after surgery. All patients were diagnosed with primary hyperhidrosis of the palms and underwent bilateral R3 or R4 sympathectomy with electric diathermy. R3 sympathectomy was performed in 104 patients between September 2001 and December 2006, while R4 sympathectomy was performed in 82 patients between January 2007 and September 2015. All operations were performed by the same surgeon. Patients were administered general anesthesia with double-lumen endotracheal intubation. The procedure was performed with the patient in the semi-Fowler position. Two 2-mm ports were used. The sympathetic chain was identified at the level of the third and fourth rib heads. The procedure was performed on the left side first. The temperature of the thenar muscle was monitored. After sympathectomy, along the upper edge of the ribs, 5–6 cm of the tissue was cauterized to cut the Kuntz fiber. Finally, the lung was re-expanded, and air was simultaneously evacuated from the pleural space using a small catheter. The same procedure was carried out on the contralateral side. The results of the intervention were evaluated as follows: overly dry hands referred to excessive dryness on the hands to the point of discomfort; mildly dry hands referred to a marked improvement, with the hands on the dry side; mildly wet hands referred to a marked im-

provement, with hands on the wet side; and overly wet hands referred to no improvement, with sweating similar to the preoperative state, and this condition was considered recurrence. CH in other regions of the body was graded according to the hyperhidrosis disease severity scale [2]. It was considered to be minimal when CH was never noticeable and did not interfere with daily activities, to be mild when it was tolerable and sometimes interfered with daily activities, to be moderate when it was barely tolerable and frequently interfered with daily activities, and to be maximal when it was intolerable and consistently interfered with daily activities. The degree of long-term overall satisfaction was categorized as follows: very satisfied, satisfied, and dissatisfied. The very satisfied and satisfied groups were categorized as satisfied when the overall satisfaction was calculated. The results were expressed as the mean with standard deviation and 95% confidence interval where appropriate. The chi-square test and independent t-test were used, and a p-value of <0.05 was considered to indicate statistical significance. SPSS for Windows ver. 14.0 (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses.

## Results

A total of 186 patients (82.3%) responded to the telephone questionnaire. There was no significant difference between the two groups with respect to the follow-up period, age, sex, body mass index, anesthesia time, or the duration of the hospital stay. The operation time was significantly shorter in the R4 group (Table 1). In the R4 group, surgery was performed later and all operations were performed by the same surgeon in the same manner; therefore, the difference in operation time was attributed to the improved skills of the surgeon. Further, 103 patients in the R4 group and 81 patients in the R3 group had plantar hyperhidrosis. Moreover, 57 patients and 52 patients in the R3 and R4 groups, respectively, had plantar hyperhidrosis accompanied by axillary hyperhidrosis. No statistically significant difference was observed in either category. As an immediate postoperative complication, one case of pneumothorax and one case of hemothorax occurred in the R3 group. There were 3 cases of pneumothorax as an immediate postoperative complication in the R4

Table 1. General patient characteristics

Variable	R3 sympathicotomy group (n=104)	R4 sympathicotomy group (n=82)	p-value
Follow-up period (mo)	40.3±14.61	35.1±22.64	0.076
Gender (male:female)	67:37	52:30	0.888
Body mass index (kg/m <sup>2</sup> )	21.29±2.36	22.05±2.94	0.051
Operation time (min)	41.14±15.89	32.4±10.87	<0.001
Anesthesia time (min)	73.75±31.8	77.85±17.2	0.110
Hospital stay (day)	1.17±0.450	1.22±0.632	0.538
Combined hyperhidrosis			
Foot	103 (99.0)	81 (98.8)	1.000
Axilla	57 (54.8)	52 (63.4)	0.237

Values are presented as mean±standard deviation or number (%), unless otherwise stated.

Table 2. Long-term results with respect to the degree of hand sweating

Variable	R3 sympathicotomy group	R4 sympathicotomy group	p-value
Overly dry	26 (25.0)	3 (3.7)	<0.001
Mildly dry	72 (69.2)	61 (74.4)	0.439
Mildly wet	3 (2.9)	11 (13.4)	0.007
Overly wet (recurrence)	3 (2.9)	7 (8.5)	0.109
Total	104 (100.0)	82 (100.0)	

Values are presented as number (%).

group. With respect to hand sweating, considerably more patients reported overly dry hands in the R3 group than in the R4 group (25% versus 3.7%,  $p < 0.001$ ). The number of patients with mildly wet hands was significantly higher in the R4 group (2.9% versus 13.4%,  $p=0.007$ ). There were three cases of overly wet hands in the R3 group (2.9%) and seven cases in the R4 group (8.5%); however, there was no statistically significant difference (Table 2). CH was observed in 101 patients (97%) in the R3 group and 54 patients (65.9%) in the R4 group, with a statistically significant difference ( $p < 0.001$ ). The degree of CH was also statistically significantly different between the two groups. There were 76 (73.1%) minimal or mild CH patients in the R3 group and 73 (89.0%) in the R4 group ( $p=0.007$ ). Sixteen patients (15.4%) had maximal CH in the R3 group, in comparison to only 4.9% in the R4 group ( $p=0.022$ ) (Table 3). CH occurred in various regions. The most common site of CH in both groups was the trunk. This was observed in 82 patients (78.8%) in the R3

Table 3. Occurrence and degree of CH

Variable	R3 sympathicotomy group	R4 sympathicotomy group	p-value
Occurrence of CH	101 (97.1)	54 (65.9)	<0.001
Degree <sup>a)</sup>			
Minimal	3 (2.9)	28 (34.1)	<0.001
Mild	73 (70.2)	45 (54.9)	0.031
Moderate	12 (11.5)	5 (6.1)	0.201
Maximal	16 (15.4)	4 (4.9)	0.022
Total	104 (100.0)	82 (100.0)	

Values are presented as number (%).

CH, compensatory hyperhidrosis.

<sup>a)</sup>According to the hyperhidrosis disorder severity score: minimal, never noticeable and never interferes with daily activities; mild, tolerable but sometimes interferes with daily activities; moderate, barely tolerable and frequently interferes with daily activities; maximal, intolerable and always interferes with daily activities.

group and in 33 patients (40.2%) in the R4 group; its incidence was significantly lower in the R4 group ( $p=0.01$ ). The second most common site of CH was the lower extremity. This was observed in 32 patients in the R3 group (30.8%) and 20 patients in the R4 group (24.4%). In addition, CH occurred on the face and scalp, in the buttock areas, and even on the whole body in certain cases. No statistically significant differences were observed between the groups in this regard. Gustatory hyperhidrosis after surgery was observed in 13 patients and three patients in the R3 and R4 groups, respectively (12.5% versus 3.6%,  $p=0.122$ ). With respect to the degree of overall satisfaction, 85.4% of the patients responded that they were satisfied or more than satisfied in the

**Table 4. Degree of overall long-term satisfaction**

Variable	R3 sympathicotomy group	R4 sympathicotomy group	p-value
Very satisfied	6 (5.8)	18 (22.0)	0.001
Satisfied	72 (69.2)	52 (63.4)	0.403
Dissatisfied	26 (25.0)	12 (14.6)	0.082
Total	104 (100.0)	82 (100.0)	

Values are presented as number (%).

R4 group, compared to 75.0% in the R3 group. This difference was not statistically significant (p=0.082). Significantly more patients were very satisfied in the R4 group than in the R3 group (22% versus 5.8%, p < 0.001) (Table 4). Due to CH, the number of very satisfied patients was smaller in the R3 group. Twenty-six patients complained of being dissatisfied in the R3 group. The cause of dissatisfaction was CH in 21 cases, overly dry hands in two cases, and overly wet hands in three cases. Twelve patients complained of dissatisfaction in the R4 group. Four patients complained of severe CH. One patient was dissatisfied due to having overly dry hands, and seven other patients complained of overly wet hands. Ten patients experienced a recurrence of palmar hyperhidrosis; in two of them, it recurred within 1 month after the surgery; in one case, it recurred within 4 months after the surgery; and in seven cases, it recurred within 1 year after the surgery.

## Discussion

Thoracoscopic sympathectomy or sympathicotomy is known as the best method of treatment for palmar hyperhidrosis [1]. Many studies have shown an improvement rate of 95% or greater immediately after surgery [3]. However, it is difficult to objectively determine whether surgery was successful, because most evaluations have been based on the patients' subjective perceptions. The occurrence of CH and the recurrence of hand sweating are very important, as they can negatively impact long-term satisfaction [1]. CH refers to a state of excessive sweating that occurs elsewhere in the body after surgery [4]. The occurrence rate of CH has been found to increase over time, while satisfaction has been found to decrease with time [1]. Many researchers are still investigating the best surgical method to reduce the incidence or

recurrence of CH, and controversies remain in this regard. The incidence and the degree of CH vary depending on the level of sympathectomy and the number of levels treated [3,5]. The early surgical approach was to ablate multiple levels, including T2 to T4; however, recent studies have reported that single-level ablation has a similar success rate as multi-level ablation, with a lower degree and occurrence of CH. Single-level ablation has therefore recently become the universal trend [3,6]. Yang et al. [4] and Wolosker et al. [7] have reported that the incidence of CH after T4 sympathicotomy was significantly less than after T3 sympathicotomy. We usually performed ablation on the sympathetic nerve at the T3 or T4 level, and the occurrence rate and the severity of CH were lower in the R4 group than in the R3 group. Therefore, we prefer R4 to R3 sympathicotomy for palmar hyperhidrosis. However, some researchers insist that there is no difference in the incidence and severity of CH between single-level and multi-level sympathectomy [8]. According to Lin and Telaranta [9], T4 and lower levels provide the major sympathetic innervation to the hands; only a small portion of T3 sympathetic tone influences palmar sweating. The fibers from T4 travel through T2 and T3 to join the brachial plexus before innervating the hand. This may explain why T3 sympathetic procedures can treat palmar hyperhidrosis, but with a higher incidence and degree of reflex sweating. In the case of T4, most of the negative afferent tone to the hypothalamus is preserved, and little or no sweating occurs. Therefore, if the sympathetic nerve is blocked at the T4 level, it does not generate a CH feedback mechanism. There have been other studies supporting a similar result. Yang et al. [4] showed that moderate CH was significantly lower in patients who underwent T4 sympathicotomy group (7.1%) than in those who underwent a procedure at T3 (23.1%). Abd Ellatif et al. [3], after conducting a retrospective study, argued that T4 sympathectomy was associated with less severe hand dryness and CH than T3 sympathectomy. Sympathetic nerve resection has changed from sympathetic ganglionectomy to sympathicotomy, in which the ganglion itself is saved and only the nerve fiber between the ganglions is cut. Sympathicotomy has a similar success rate to ganglionectomy and a lower complication rate; furthermore, the procedure is simpler [10]. Patient sat-

isfaction is not only related to the reduction of palmar sweating but also to the patient's tolerance of complications (recurrence, overly dry hands, and CH) [1]. In our case, there was a similar improvement in palmar sweating between the R3 and the R4 groups. The incidence and the severity of CH, as well as the incidence of overly dry hands, were significantly lower in the R4 group. Therefore, we can infer that the overall long-term satisfaction with the procedure was higher in the R4 group.

In conclusion, this study was performed to compare the long-term results of R4 sympathectomy and R3 sympathectomy. In the R4 group, there were fewer cases of overly dry hands, a lower CH rate (67.1% versus 97.1%), and higher satisfaction (84.2% versus 75%) than in the R3 group. Furthermore, there were significantly more very satisfied patients in the R4 group. There were fewer dissatisfied patients in the R4 group (25.0% versus 14.6%), but this was not statistically significant. Thus, we can conclude that R4 sympathectomy is preferable to R3 sympathectomy for treating palmar hyperhidrosis.

### Conflict of interest

No potential conflicts of interest relevant to this article are reported.

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