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The Correlation Between the Method of Sympathetic Ablation for Palmar Hyperhidrosis and the Occurrence of Compensatory Hyperhidrosis: A Review

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Abstract

Background Upper dorsal sympathectomy achieves excellent long-term results in the treatment of primary palmar hyperhidrosis. Compensatory hyperhidrosis (CHH) remains an unexplained sequel of this treatment, attaining in a small percentage of cases disastrous proportions. It has been claimed that lowering the level of sympathectomy (from T2 to T3 and even T4), substituting resection by other means of ablation, and limiting its extend reduce the occurrence of this sequel. This review was designed to evaluate the validity of these claims.

Methods A MEDLINE search was performed for the years 1990–2006 and all publications about thoracoscopic upper dorsal sympathectomy for hyperhidrosis were retrieved.

Results The search identified 42 techniques of sympathetic ablation. However, pertinent data for the present study were reported for only 23 techniques with multiple publications found only for 10. The only statistically valid results from this review point that T2 resection and R2 transection of the chain (over the second rib) ensue in less CHH than does electrocoagulation of T2. Further comparisons were probably prevented due to the enormous disparity in the reported results, indicating lack of standardization in definitions.

Conclusions The compiled results published so far in the literature do not support the claims that lowering the level of sympathetic ablation, using a method of ablation other than resection, or restricting the extend of sympathetic ablation for primary palmar hyperhidrosis result in less CHH. In the future, standardization of the methods of retrieving and reporting data are necessary to allow such a comparison of data.

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Introduction

Hyperhidrosis is a pathological condition of excessive secretion of the eccrine sweat glands in amounts greater than required for physiological needs [1]. It may develop secondary to a variety of medical disorders [2] or it may be primary of unknown etiology. A multitude of therapeutic modalities have been proposed for the treatment of primary hyperhidrosis (PHH) [3, 4]. However, the only effective procedure to permanently abolish hyperhidrosis is ablation of the upper thoracic sympathetic chain. The several open approaches used in the past [5] are now supplanted by the endoscopic technique. Sympathectomy bears sequels, of which compensatory hyperhidrosis (CHH) is the gravest and most commonly observed [6, 7]. This phenomenon consists of increased perspiration after the operation in a part of the body not affected anatomically by the sympathectomy [8]. An old study [9] suggested that the total body amount of perspiration was unchanged by the sympathetic ablation, therefore, the increase of sweating in one part of the body representing a compensation for the arrest of sweating produced by the sympathetic ablation in another area. Hence the term "compensatory hyperhidrosis" was adopted. However, these results were not confirmed by another recent study [10]. Furthermore, CHH does not develop in all patients [11] and does not necessarily present immediately, but may appear even as late as 6 months postoperatively [12]. The degree of CHH is variable [13], and it may be alleviated or abate spontaneously [9, 14]. Moreover, arrest of sweating in the "compensatory area" by botulinum-toxin A injections did not result in increased sweating in a "new" area [15]. Finally, the opposite effect—decreased sweating in other parts of the body—also has been reported after sympathectomy [13, 14, 16]. Thus, the mechanism of CHH seems to be more complex than simple compensation for thermoregulatory purposes, and remains enigmatic and obscure. To reduce the incidence of this sequel, which is extremely troublesome in a certain percentage of operated patients [6], numerous variations in the type and extent of the technique of sympathetic ablation have been advocated. To evaluate the correlation between the technique and the subsequent degree and occurrence rate of CHH, we reviewed the literature pertinent to the results of thoracoscopic sympathectomy for primary palmar hyperhidrosis.

Materials and methods

Using the PubMed search engine, a quest was made for all publications that involved thoracoscopic sympathectomy for palmar hyperhidrosis listed in MEDLINE and published during the period January 1, 1990 to December 31, 2006. Retrieval was performed by the following key words and phrases: Hyperhidrosis AND Thoracoscopic sympathectomy; Hyperhidrosis AND Endoscopic sympathectomy; Palmar hyperhidrosis; Dorsal OR Thoracic AND Sympathectomy; Compensatory hyperhidrosis OR Compensatory sweating. Additional pertinent articles published before 1990 were obtained from the lists of references in the former publications. Reviews, editorials, letters to the editor, reports on the anatomy of the sympathetic system, and articles on the pathophysiology of its ablation were excluded. All articles describing series of patients who underwent thoracoscopic upper dorsal sympathectomy for palmar hyperhidrosis were identified, collected, and reviewed. Excluded from the collective review were case reports, articles reporting small series (less than 10 patients), articles reporting mixed series (more than one operative method and/or indications for surgery) in which separate data for each method or indication were not supplied, and articles missing follow-up on complications and sequels. The remaining articles were grouped by authors. Some authors periodically publish their data; the patients included in one publication were reviewed with some more cases in a subsequent study. To prevent inclusion of the same patients more than once in the collective review, only the last such publication of each group of authors was included in the present study. In case of double publications of the same series, only one was included in the present review.

The remaining articles were grouped according to the method of sympathetic ablation. The data that were retrieved included the number of patients, the percentage of immediate failures (persistent overperspiration of the hands), the number of patients for which a follow-up was documented, and the occurrence of CHH.

The various methods of sympathetic ablations were grouped as following: resection of parts of the sympathetic chain, electrocauterization of parts of the sympathetic chain, transection of the sympathetic chain at various levels, transection of sympathetic rami communicants (ramicotomies), and sympathetic ablations using clips.

Methods and level of ablations for which only one or two references were found could not be compared statistically. Therefore, comparison was made only for those methods and extent of ablations for which more than two reports were found.

We examined the success of sympathetic ablation by dividing the percentage of CHH by the percentage of obtained dry hands (morbidity/success index). The best possible index is zero, whereas the worst index should be one (or higher if CHH would occur despite failure to abolish PHH).

Statistical analysis was performed by using the Mann–Whitney nonparametric test. $p \leq 0.05$ was considered statistically significant.

Results

After elimination of the nonpertinent retrieved articles (reviews, editorials, letters to the editor, etc.), 216 relevant papers were identified. After examining these studies, 87 publications were selected for the present review. The remaining 129 papers were eliminated. The reasons for their elimination are listed in Table 1.

The search identified 42 reported techniques of sympathetic ablation. However, pertinent data for the present study were reported for only 23 techniques. These were grouped and the data are reported in Table 2. The remaining published techniques, which were not included due to insufficiently reported data, are listed in Table 3.

An enormous variability in reported results was found for each technique and level of ablation. To illustrate this variability, the reported incidence of CHH is presented for T2–T3 resections (Fig. 1), T2–T3 cauterizations (Fig. 2), and R2–R3 transection of the sympathetic chain (Fig. 3).

Table 1 Articles excluded from the collective review

Reference numbers	Reason for elimination
[17–32]	Case reports and series with less than 10 patients
[33–49]	Series including thoracoscopic procedures for mixed indications (not only HH)
[50–59]	Sympathectomies performed for HH but not PHH, and for blushing
[60–65]	Sympathectomies performed for various sites of HH, and for blushing
[11, 66–87]	Sympathectomies performed for HH, including other than PHH
[88–101]	Series including various methods of sympathetic ablation
[102–111]	Articles reporting insufficient data pertinent to the present study
[112–114]	Series included in the one published in Ref. [188]
[115–119]	Series included in the one published in Ref. [187]
[13]	Series included in the one published in Ref. [157]
[120–126]	Series included in the one published in Ref. [218]
[127–129]	Series included in the one published in Ref. [165]
[130–135]	Series included in the one published in Refs. [216] and [227]
[136, 137]	Series included in the one published in Ref. [185]
[138]	Series partially included in the one published in Ref. [222]
[139]	Series included in the one published in Ref. [209]
[140]	Series included in the one published in Ref. [90]
[141]	Series included in the one published in Ref. [217]
[142, 143]	Series of recurrent ablations for failure of the first ones

Table 2 Results for the various methods of sympathetic ablations

Type of sympathetic procedure	Level of sympathetic procedure	References (#)	No. of patients	Immediate result (% of dry hands)	Follow-up (no. of patients)	CHH (no. of patients)	CHH/success index
Resection by diathermy	A	[144–148]	346	100	299	37.1	0.371
	B	[149]	140	100	111	76	0.76
	C	[148, 150–159]	1221	100	1152	54.9	0.549
	D	[155, 160–166]	943	100	793	67.1	0.671
	E	[167]	20	90	20	70	0.778
Cauterization	A	[168–172]	982	85.4	718	82.6	0.967
	B	[173]	24	100	24	4.2	0.004
	C	[174–191]	2968	96	2519	64.04	0.667
	D	[192–199]	405	92	341	64.8	0.704
	F	[200, 201]	220	91.3	110	96.4	
Transection by diathermy	G	[202]	164	98.4	104	39.0	0.405
	H	[203–206]	140	96.6	140	54.3	0.562
	I	[207]	30		30	16.7	
	F	[208–218]	3526		3174	76.2	
	J	[219]	14	100	14	35.7	0.357
	K	[220, 221]	56	100	56	33.1	0.331
Ramicotomy	B	[222]	68	0	46	67.4	
	C	[223]	13		13	23.08	
	L	[224]	63	100	59	47.5	0.475
Clipping	M	[225]	52		52	85.4	
	N	[222]	40		40	94.1	
	O	[226]	52		52	87.5	
	P	[227]	70	71.9	70	19.4	0.27

A, of T2; B, of T3; C, of T2–T3; D, of T2–T4; E, of T1–T4; F, over R2–R3; G, between T1–T2; H, over R2; I, over R3; J, over R3–R4; K, over R2–R5; L, of T2–T6; M, above and below T2; N, between T2–T3; O, over R4; P, above and below T4; T, thoracic sympathetic ganglion; R, rib

Table 3 Additional methods of sympathetic ablation (not included in the compiled data)

Method	Type	References
Resection	T1–T3 diathermy resection	[23]
	T2–T5 diathermy resection	[39, 88, 93]
	T1 scissors resection	[101]
	T2–T3 scissors resection	[101]
	T2–T4 scissors resection	[72]
Electrocauterization	T2–T5 electrocauterization	[19]
	T3–T5 electrocauterization	[60]
	T1–T4 electrocauterization	[91]
	R3 upper border electrocauterization	[199]
Transection of the sympathetic chain	R2 and R3 diathermy transection and ramicotomies	[28]
	R2, R3, R4, R5, and R6 diathermy transection	[34]
	T2–T5 diathermy transection and ramicotomies + Kuntz transection	[44]
	T4 diathermy transection	[63]
	T2 transection by harmonic scalpel	[78]
	T2 and T3 transection by harmonic scalpel	[78]
Other electroablation	T2–T4 electrocauterization of ganglia + transection of chain	[228]
Clipping	T2	[229]
	T2, T3, T4	[38]
	T3, T4	[62]
	R3, R4	[32]
Miscellaneous	Laser photocoagulation (various levels)	[20, 92]
	T2 thoracoscopic phenol injection	[33]

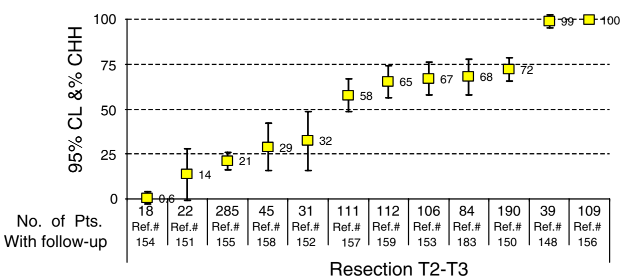

Fig. 1 Reported CHH in series in which T2–T3 resections were performed. The squares represent the means and the bars represent the standard deviations. *CL* confidence limit

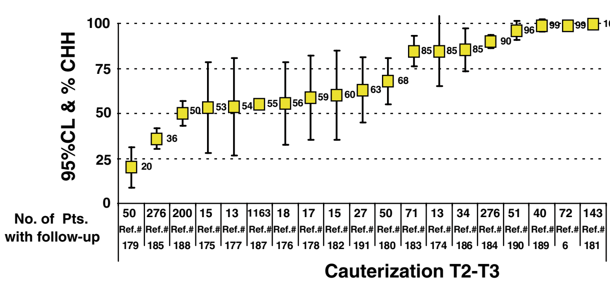

Fig. 2 Reported CHH in series in which T2–T3 cauterizations were performed. The squares represent the means and the bars represent the standard deviations. *CL* confidence limit

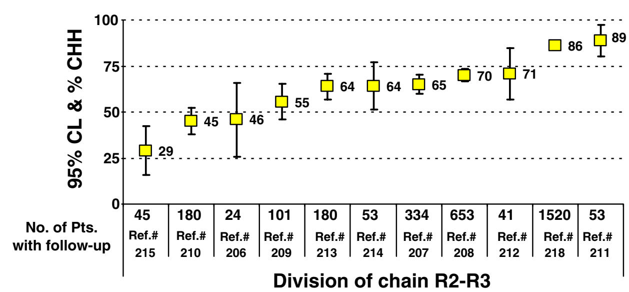

Fig. 3 Reported CHH in series in which R2–R3 chain transections were performed. The squares represent the means and the bars represent the standard deviations. *CL* confidence limit

In Fig. 4, the compilations of the data regarding the occurrence of CHH are reported for each of the techniques of resection, cauterization, and transection of the sympathetic chain for each of which more than three publications were found. The statistical data and statistical comparison of the percent of CHH of these eight procedures are listed in Table 4. For the remaining two methods (ramicotomies and clipping), only one publication was found for each anatomical level, therefore, statistical evaluation and comparison were not possible.

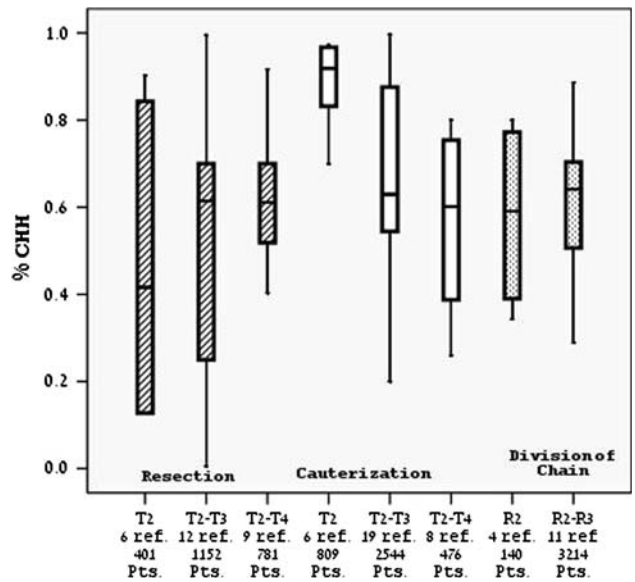

Fig. 4 Compilation of results for the occurrence of CHH after the commonest sympathetic procedures. Fifty percent of cases have values within the boxes. The upper point of the bars represents the largest observed value that is not outlier, whereas the lower point of the bars represents the smallest observed value that is not outlier. The horizontal line within the boxes represents the median value

The morbidity/success index for the various techniques is reported in Table 2. Statistical comparison of the indexes for T2–T3 resections, T2–T3 cauterizations, and R2–R3 chain transections is given in Table 5.

Table 5 Comparison of the CHH/success indexes of T2–T3 resections, T2–T3 cauterizations, and R2–R3 chain transections

Types of procedures	*p* value
T2–T3 resection vs. T2–T3 cauterization	0.09
T2–T3 resection vs. R2–R3 transection of chain	0.126
T2–T3 cauterization vs. R2–R3 transection of chain	0.89

Statistical descriptives of the data presented in the upper part of the table

Group	T2–T3 resection	T2–T3 cauterization	R2–R3 chain transection
n	12	17	9
Mean	0.52	0.73	0.62
Median	0.62	0.77	0.64
Standard deviation	0.32	0.25	0.18
Minimum	0.01	0.2	0.289
Maximum	1	1.06	0.887

Discussion

Disparity of results

Despite the vast number of pertinent publications, more than half of the reported series could not be included in the present study. The reason is the enormous variability in

Table 4 Comparison of the occurrence (% of means) of CHH in the various types of sympathetic procedures

Types of procedures	*p* value	Types of procedures	*p* value
T2 resection vs. T2–T3 resection	0.34	T2 resection vs. T2 cauterization	**0.028**
T2 resection vs. T2–T4 resection	0.125	T2–T3 resection vs. T2–T3 cauterization	0.27
T2–T3 resection vs. T2–T4 resection	0.62	T2–T4 resection vs. T2–T4 cauterization	0.67
T2 cauterization vs. T2–T3 cauterization	0.086	T2 resection vs. R2 transection of chain	0.33
T2 cauterization vs. T2–T4 cauterization	**0.007**	T2–T3 resection vs. R2–R3 transection of chain	0.6
T2–T3 cauterization vs. T2–T4 cauterization	0.24	R2 transection of chain vs. T2 cauterization	**0.03**
R2 transection of chain vs. R2–R3 transection of chain	0.79	T2–T3 cauterization vs. R2–R3 transection of chain	0.6

Statistical descriptives of the data presented in the upper part of the table

	Resection			Cauterization			Chain transection	
	T2	T2–T3	T2–T4	T2	T2–T3	T2–T4	R2	R2–R3
Mean	0.39	0.52	0.64	0.88	0.69	0.57	0.58	0.62
95% confidence interval for mean								
Lower bound	0.03	0.31	0.5	0.77	0.58	0.39	0.22	0.5
Upper bound	0.83	0.73	0.78	0.99	0.8	0.75	0.94	0.74
Median	0.22	0.61	0.61	0.92	0.63	0.6	0.59	0.64
Standard deviation	0.35	0.32	0.18	0.11	0.23	0.21	0.23	0.18
Minimum	0.126	0.006	0.403	0.7	0.2	0.26	0.343	0.289
Maximum	0.902	0.995	0.917	0.972	0.997	0.8	0.8	0.887

Note: The bold values are statistically significant results data compilation and report. Even in apparently similar procedures, the wide disparity of the reported occurrence of CHH as illustrated in Figs. 1–3 underlines the lack of standardization in reporting data. It is inconceivable that exactly the same procedure would produce such a disparity of resulting CHH as 0.6% in one series and 100% in another. There are two explanations for this disparity: lack of standardization in definitions and anatomical variations.

Lack of standardization (different definitions of CCH, intensity of questioning, and length of follow-up) is probably the most important one. If only the patients who complained of CHH are listed as having developed this sequel of sympathectomy, the number will be low. If on the other hand, a meticulous inquiry is made concerning increased humidity in other areas of the body irrespective of its quantity, a high percentage of patients would be considered as having CHH. The figure would attain the 100% if specific laboratory measurements (sudometry) of the amount of perspiration are made in the areas prone to CHH before and after the sympathetic ablation [230].

Anatomical variations are another possible cause for disparity of results. The anatomy of the upper sympathetic chain has been studied and described in several studies. Although the second thoracic ganglion is considered to be located in the second intercostal space [231, 232], some other studies have shown a substantial variability. Chung et al. [233] have found in their cadaver anatomical study that only 50% of T2 ganglia were located in the second intercostal space, 9.1% of T2 ganglia were fused with the stellate ganglion, and 6% were located over the third rib. Variability exists not only concerning the level of the T2 ganglion, but also in the location of the chain along the horizontal axes of the rib heads [234]. Another anatomical inconsistency was reported regarding alternate neural pathways [231], the rami communicants [235], and the presence of the nerve of Kuntz (connecting the second intercostal to the ventral ramus of the first thoracic nerve) [236]. Therefore, if decision on the level of sympathetic ablation is made by rib count without observing the exact anatomy of the chain, the sympathetic ablation may be performed at a level different than the intended one.

Another cause for confusion in reported data is the count of the ribs. This is the intraoperative means of locating the appropriate ganglia. However, some authors claim that the first rib cannot be observed during thoracoscopy [237], whereas the majority of surgeons consider the uppermost observed rib to be the first one. In fact, it seems that the first rib is visible in some patients but can be only palpated in others [191]. Failure to achieve sympathicolysis has been attributed to erroneous rib count [238]. To overcome the problem, sympathetic ablation by clipping has been suggested [71]. However, unless intraoperative radiography is performed, clip application will not prevent incorrect estimation of the level as shown by Chou et al. [64], who reported 4.4% of clipping at an incorrect level, assessed only postoperatively.

A further bias in the published results may be due to the almost invariable use of diathermy, not only for thermocoagulation of ganglia or transection of the sympathetic chain, but even for dissection of the chain and resection of ganglia. The heath produced by the diathermy propagates and results in neural damage beyond the intended procedure. This additional injury cannot be measured but may explain such sequels as the occurrence of Horner's syndrome [239] and brachial plexus injury [240]. The use of the harmonic scalpel instead of diathermy may eliminate collateral (and unpredictable) damage resulting from the heath propagated by the diathermy. The published data in which this instrument was used are too limited to allow any conclusions.

Methods and level of sympathetic ablation

With the advent of endoscopic surgery, two basic changes in the technique of upper limb sympathetic denervation were introduced: 1) instead of resecting ganglia, some surgeons destroyed the ganglia or merely transected the sympathetic chain by electrocautery, and 2) instead of the second ganglion (T2), a lower than T2 ablation of the chain was chosen. In both of these modifications of the classical (T2 resection) approach for treating PHH, if failure occurs, contrary to the difficulty in reoperation after the open approaches, reoperation by endoscopy is relatively easy, both technically and clinically.

The reason for preferring ganglionic thermoablation or thermotransection of the chain is due to the relative simplicity of the latter procedure compared with the more time-consuming and demanding technique of endoscopic resection. Furthermore, although T2 resection achieves dry hands in almost 100% of cases [241], the results of thermoablation are usually not much inferior to those of resection [203]. However, exceptionally high percentages of recurrences of palmar overperspiration have been reported [242]—25.6% for T2 thermoablation—far exceeding the average published results (4.8%) [241].

During the period of open surgery, the second thoracic ganglion was considered to be the key to the sympathetic innervation of the upper extremity [144, 243]. Therefore, it was invariably accepted that this is the ganglion that should be resected to obtain dry hands, resection being the standard method of ablation. Recent anatomical studies confirm this anatomical supply to the hand [231], as did a recent sudometric study [230]. However, this accepted neuroanatomical standard has been challenged in recent years. Indeed, performing lower than T2 sympathetic ablations abolish or reduce palmar sweating in a large percentage of cases. In a recent publication, Drs. Lin and Telaranta [244] proposed what they called the Lin-Telaranta classification for the sympathetic innervation of the hand, axilla, and face. They claimed that to obtain sympathetic denervation of the hand while reducing the occurrence of CHH, T4 ganglion ablation only should be performed, thus preserving what they considered the afferent sympathetic fibers to the anterior portion of the hypothalamus, originating according to their hypothesis from the T2 and T3 ganglia. This is an interesting hypothesis, but as far as neuroanatomical pathways are concerned, they can be demonstrated only by appropriate stains, and no such stains have been performed to prove their hypothesis. Furthermore, recurrence rates of almost 23% have been reported for T4 ablations [242]. The main considered reason for recurrence is inadequate ablation of the sympathetic chain and not nerve regeneration [245]. It seems that such a high percentage of recurrences after T4 ablation and lack of stains to show the exact neuroanatomical pathways question the validity of the Lin-Telaranta classification. Regarding the claim that T4 ablations, compared with higher sympathetic procedures, reduce the amount of CHH [135, 226, 242], a compilation of data was not possible. In the first report [226], ablation was achieved by clipping the chain above T4, and in the second report [135] above and below T4 clipping was used. In the third report [242], the sympathetic chain was cauterized over R4 and R5. Thus, on clinical basis as well, the data published so far in the literature are insufficient to confirm the Lin-Telaranta hypothesis. Similarly, from the compiled data in the present review, no conclusion can be drawn for the T3 level of ablation. Only sporadic valid reports for only T3 ablations were found, each using a different technique [149, 173, 207, 222], making statistical comparison impossible. In the remaining studies, T3 and T4 ablations were performed jointly with another adjoining ganglion. However, even for the remaining levels and methods of ablation, due to the enormous discrepancies between reported results, the data compiled in the present review yielded only restricted information on the subject. If the level of ablation is responsible for the subsequent occurrence of CHH, one should expect approximately the same results for T2 resection and T2 thermocauterization, which according to the present review is not the case: T2 resection results in less CHH than T2 thermocauterization, as does transection of the sympathetic chain over the second rib (R2). Schmidt et al. [60] claimed that restricting the extend of resection reduces the subsequent occurrence of CHH, while Lesèche et al. [101] obtained opposite results. From the data of the present review, restricting resection resulted in less CHH only for T2 in comparison to T2–T4 resections. However, these statistical results should be considered with caution because of the enormous disparity of data. All other comparisons of levels, extend, and methods of ablation did not reach statistical significance. Thus, the question of how to reduce CHH after sympathetic ablation for PHH remains unanswered. Future studies, based on standard definition of terms and standardization of the method of follow-up, are required.

Methods of evaluating results

In the past, dry hands were considered the positive result of sympathectomy for PHH, although persisting or recurrent moisture of the hands (similar to normal perspiration) cannot be regarded as failures [246]. Therefore, many authors consider reduction of palmar perspiration as a positive result of surgery. However, there is no quantitative measurement of the amount of reduction. Thus, many authors evaluate their results by the satisfaction of the patients. There is no doubt that sympathetic ablation for PHH—being a procedure for functional and esthetic improvement—should result in the patient's satisfaction. However, this method possesses two drawbacks: it is not a physiological evaluation of the procedure, and patient satisfaction reflects the totality of results, including failure to obtain dry hands, too dry hands, recurrence of palmar perspiration, and the development of any sequel, including CHH and Horner's syndrome. Furthermore, to use "patient satisfaction" as a tool of comparing results of various techniques, levels, and extend of sympathectomy, standardization in the method used for evaluating the satisfaction also should be used. Such standardization should include the time lag between the operation and the point at which the data were obtained. No such standard has been established so far. However, if we seek to learn the physiologic outcome of the procedure concerning a specific sequel, an objective method of evaluating results is possible.

Morbidity/success index

In the present study, to evaluate the merit of sympathetic ablations for hyperhidrosis based on the occurrence of CHH, we used an index comparing the occurrence of CHH to the percentage of obtained dry hands (morbidity/success index). We were unable to calculate this index for many types of procedures due to insufficiently published data. For the most commonly published level of sympathetic ablation (T2–T3), the lowest mean index was for resections and the highest for cauterization (Table 5). However, no statistical significance was found while comparing these results. As already mentioned, the bias of this index is in its reflecting only the pathophysiological success of the procedure as far as dry hands and CHH result. It does not necessarily correlate with the satisfaction of the patient from the operation. Furthermore, it does not take into account the severity of preoperative sweating or CHH.

Conclusions

The pathophysiology of CHH remains obscure. The claim that lowering or restricting the level of sympathetic ablation reduces the occurrence of CHH is not supported by the data currently published in the literature, nor can a decision be made, based on these data, which method of sympathetic ablation is preferable. To obtain this vital information from future publications, definition of terms and standardization of the method of follow-up are required. Use of a quantitative method for determining CHH (sudometry) will prevent the enormous disparity in published results. The International Society of Sympathetic Surgery has produced a standard questionnaire for compilation of data and follow-up. It can be retrieved from the website of the Society: www.isss.net (enter: "About ISSS" and then "Recommendations"). We urge all surgeons with a special interest in sympathetic surgery to use this questionnaire prospectively and allow future compilation of standardized data so that the two paramount questions of sympathetic ablation, namely lowering the occurrence of CHH and the best method of sympathetic ablation, be elucidated.

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