Surgical Techniques for the Realization of Thoracic Sympathectomy

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Introduction

Primary hyperhidrosis does not have a well-established cause. Anatomically, we know that there is a sudomotor efferent pathway that originates in the cerebral cortex and makes connections in the hypothalamus and medulla, crosses before the bridge, descends through the lateral horn of the spinal tract, connects to the sympathetic ganglion, and reaches the sweat glands by fibers postganglionic. The neurotransmitter is acetylcholine, which binds to the muscarinic receptors of the sweat glands [1]. This activation is part of an atavistic neural response that prepares the individual to run or fight and is mediated by the sympathetic autonomic nervous system [2–8].

The fight–flight reaction involves a complex model involving the central nervous system (CNS), adrenal system, and autonomic nervous system in target organs [9].

In the CNS, the stimulus of fear can occur in two ways. The first involves the cortex, and the second involves the amygdala and is very rapid [10].

The more proximal the pathway, the more intense the stimulus. In the case of the fight–flight response, the pathway is proximal with intense stimulus.

Basically, there are two ways in which the fear stimulus can travel—the high road and the low road:

- The high pathway involves the adrenocortical system.
- The lower lane involves the amygdala and the sympathetic system.

The autonomic nervous system is divided into sympathetic and parasympathetic. In the case of the low path in the fight–flight response, only the sympathetic is activated. Several actions of the autonomic nervous system occur in the various target

The original version of this chapter was revised. A correction to this chapter can be found at https://doi.org/10.1007/978-3-319-89527-7_35

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M. P. Loureiro et al. (eds.), *Hyperhidrosis*,
https://doi.org/10.1007/978-3-319-89527-7_19

organs. In the skin, the sympathetic response involves bruising, vasodilation, and sweating.

The effector stimulus leaves the marrow through the anterior branch, meets the spinal nerve, and through its anterior branch travels the communicating branches to the ganglion in the sympathetic chain.

In the case of the sweat glands, the sympathetic preganglionic branch is short and the postganglionic branch is long. The neurotransmitter is acetylcholine, which binds to the muscarinic receptors. In the anatomy of the skin we can observe the existence of sweat glands, eccrines, and apocrines. Those responsible for hyperhidrosis are the eccrine glands. They have no association with the hair follicle and can produce the equivalent of 10 L of sweat per day, if an individual would sweat all day long. We must remember that the pathways assume anatomical variations that may affect the final response to an intervention in the sympathetic system.

Typical primary hyperhidrosis is diagnosed clinically. There are no commercially available tests to quantify it effectively and, in addition, they would not be able to stablish a differential diagnosis to secondary hyperhidrosis. The typical clinical findings are exaggerated sweating that is localized, has occurred since childhood, with a family history, linked to emotion, and does not occur during sleep.

Scientists from Newcastle in England have shown that wrinkled hands and feet increase the adhesion of these surfaces, improving performance when moist [3]. This fact may be related to the fight–flight response, increasing grip in the hands and feet and explaining why 90% of primary hyperhidrosis occurs in these regions. A US publication has studied these effects in primates in depth [11]. They compared this phenomenon with flat or furrowed tires and speculate that in wet conditions this phenomenon would increase the grip of the primates.

The main differential diagnoses are panic syndrome and secondary hyperhidrosis. Both have a major impact on the outcome of surgical treatment of hyperhidrosis.

Panic syndrome typically begins suddenly, during adolescence or young adulthood. Sweating is usually widespread and can occur during sleep. Hyperhidrosis is not usually the predominant symptom, occurring simultaneously with tachycardia, chest pain, dry mouth, perception of death, depersonalization, suffocation, tingling, and tremors.

Secondary hyperhidrosis occurs through several different stimuli, unrelated to fear, has a later onset, may occur during sleep, and is not localized. Sympathectomy often triggers or worsens its manifestation. As there are no examinations to differentiate it from primary hyperhidrosis, and definitive treatment may worsen it, the therapeutic choice must be made with great care.

The treatments can be divided into palliative or definitive, and the palliative effect is dependent on its use. Among the several forms of palliation, we highlight the use of anticholinergic drugs.

On the other hand, the universally validated definitive treatment is sympathectomy. Among the surgical forms, we believe that sympathectomy with ganglion ablation will provide two complementary effects for the control of typical primary hyperhidrosis. Effect A involves the anterior effector branch of the sympathetic system and has the effect of abolishing the eccrine sweat action at that treated level. Effect B involves the exchange of afferent and efferent information between the limbic system and the sympathetic system, improving the effect of the fight–flight response. In this sense, secondary hyperhidrosis in untreated body regions may appear or worsen. Surgery is indicated only in cases of typical primary hyperhidrosis, in order to avoid the onset and/or worsening of secondary hyperhidrosis.

Thoracic Sympathectomy Surgical Techniques

Introduction

In order to offer the best treatment for patients with primary palmar hyperhidrosis, improving their psychological symptoms, social, and occupational challenges, we have to keep in mind some important concepts. Conservative treatment is not always effective, and sometimes patients are not compliant to use medication indefinitely. When this occurs and other forms of treatment are not accepted, surgery becomes the best option for definitive treatment [12].

Surgical techniques that open through the posterior, transaxillary, or supraclavicular spinal muscles are currently avoided for a variety of reasons, among them a very high morbidity for the disease in question associated with an aesthetic result that is currently unacceptable. Due to all of the reasons given earlier, minimally invasive surgery is the gold standard for the treatment of hyperhidrosis. While minimally invasive surgery is understood as the use of the videothoracoscope, this is now being extended to other techniques such as endoscope use, as discussed later in this chapter.

With the advent of video and advancement in endoscopic video-assisted techniques, the thoracoscopic approach, first described by Kux in 1951, has undergone rapid progression and is now widely accepted as the approach of choice [13]. Further discussion has upraised regarding the technique to be used: although the video-assisted approach has been accepted as the approach of choice with minimal postoperative morbidity and near perfect success rate [14–16], the optimal technique remains controversial. Many aspects have to be reviewd such as method of interrupting the sympathetic chain, level of intervention and thoracic approach.

The optimal procedure, or the best option, such as sympathicotomy or sympathectomy (excision), remains also controversial. What is the best form of sympathetic chain ablation: use of electrocautery or other forms of energy?

In this chapter we will discuss all of the questions raised here and describe the techniques employed, the numerous variants available, combinations of techniques, patient positioning and/or trocars, materials used, sympathetic operated levels, and the section method used. Each of these is discussed in detail, including a description of the technique used and the results achieved.

Chain Approach and Patient Positioning

Anterior Approach

In the anterior approach [12], general anesthesia is induced and intubation is performed with a double lumen endotracheal tube to allow monopulmonary ventilation most of the time. This type of intubation is not mandatory; intubation can be performed with a simple tube and using apnea during the introduction of trocars and ablation of the sympathetic chain. In this method, the patient is placed in a semi-seated position, with an angle of 75 °, and the arms abducted 90 ° on the shoulder. The operating table is also inclined to 15 °. With this placement, the lung on the operated side falls toward the diaphragm.

After initiation of monopulmonary ventilation or apnea (in the case of intubation with single tube), a 5 or 10 mm trocar is inserted anteriorly into the pleural cavity generally in the fourth intercostal space. In this approach (the most commonly used) there are various incision sites that can be used, among them:

– the line of the mammary sulcus (in women), at the bisector of the external quadrant of the breast;
– the line of the pectoralis major (in men), in the bisector of the external quadrant of the muscle;
– fourth or fifth intercostal spaces in the anterior axilla line;
– incision infra-areolar, in the external quadrant of the areola (in men).

The first incision is used to place the 5 or 10 mm optics (camera) and guide the second trocar. The second incision is made in the third intercostal space in the median axillary line, 5 mm, for introduction of the working instrument.

After visual confirmation of the head of the second, third and forth ribs, the section of the sympathetic chain is made using the working instrument (scissors, electrocautery, or harmonic scalpel) through the 5 mm trocar of the third intercostal space.

Finally, the pleural cavity is evacuated through the lateral line, trough a cannula placement, and the trocars are removed under the application of continuous positive airway pressure. Usually muscle and skin are closed, and there is no need for thoracic drainage maintenance.

Posterior Approach

The use of the posterior approach [17] is justified by its authors due to the fact that in the lateral approach, the lung moves to the medial-ventral side and in the anterior approach, the lung moves caudally, partially obscuring the view of the sympathetic chain, which sometimes forces us to take the lungs out of the operative field using a work tool and this can cause injury leading to unwanted fistulas. In addition to these advantages, monopulmonary ventilation is unnecessary, thus using the simple endotracheal tube, which theoretically is less traumatic than a double lumen tube and may result in lower morbidity [18]. The tidal volume should be reduced by 30%; this reduction is compensated by a higher frequency of ventilation under capnographic control.

With the posterior approach, the lung moves to the ventral side of the thorax. Remarkably, after introduction of the videoendoscope, the sympathetic chain immediately appears, without the need for manipulation of the lung. This approach offers better visibility—according to its proponents—and, like the previous approach, bilateral treatment is possible in a single session without changing the patient's position (in contrast, repositioning is mandatory in the lateral approach). Better visibility and exposure of the sympathetic chain in relation to the other approaches is described as occurring with this technique.

The patient is placed in a jackknife position, with ventral decubitus and greater flexion in the hips, to obtain a thoracic kyphosis and to open the intercostal spaces as much as possible. The arms are bent 90 ° at the elbows, and the shoulders are maximally abducted. The forearms are immobilized with arm supports to lateralize the scapulae.

For the sympathetic chain approach by the posterior wall, a Verres needle is inserted into the pleural cavity through the sixth intercostal space, distally to the lower angle of the scapula. Pneumothorax is created by infusing 1000 mL of carbon dioxide with a maximum pressure of 4 mmHg. The Verres needle is then replaced by a 10 mm trocar suitable for the thoracoscope.

Two operative trocars are inserted medially into the scapula in the second and fourth intercostal spaces. One of these trocars is also suitable for a stapler device. The force of gravity moves the lungs to the ventral side of the thorax. This gives excellent visual exposure of the sympathetic chain without the need for pulmonary collapse or the use of a pulmonary valve. After locating the second to fifth ribs, the parietal pleura medial to the sympathetic chain is incised with an electrosurgical hook. The T2 to T4 thoracic ganglia and their interconnecting fibers are resected by electrocoagulation.

The sympathetic chain distal to the star ganglion is resected by scissors without the use of electrocoagulation to avoid damage to this ganglion. In the case of face hyperhidrosis or flushing, resection of the distal third of the starved ganglion with scissors is described.

After the sympathectomy, a chest drain is placed through a trocar and suction drainage of 10 cm H_2O is applied, and the lung is inflated under direct camera vision. The procedure is repeated on the other side during the same operation without the need to change the patient's position.

All patients in the described series were treated postoperatively with chest drainage for at least 24 h. Although recent literature shows that routine thoracic drainage is unnecessary, some authors emphasize that postoperative pneumothorax can be a cause of serious complications.

Lateral Approach

In the lateral approach [19], the patient is positioned in the lateral decubitus position, with cushions placed in the tip of the scapula. The legs are positioned so that the ipsilateral leg is flexioned, and the contralateral extended, with protection between them. The ipsilateral arm to the decubitus is extended, while the arm above is positioned with a 90 ° angle between the shoulder and the middle axillary line and also the elbow. The intubation is selective.

After the patient is positioned, the operative side is collapsed and the pleural cavity is accessed by two trocars. The incisions are made in the second or third intercostal space in the mid axillary line (trocarter of 5 mm), and in the fifth intercostal space in the posterior axillary line (5 or 10 mm). Generally the patient should be rotated to allow gravity to retract the lung away from the surface of the spine.

After these steps, all the chain and the chain section itself should be identified. In the series described, surgery was terminated by the introduction of a single thoracic tube number 16F connected to the active suction of −20 cm H_2O, for 24 hours and withdrawn in the immediate postoperative period or first PO - postoperative day.

The great disadvantage of this technique, besides the mandatory use of selective intubation, is that the patient must be repositioned and the same surgical procedure must be performed on the opposite side.

Chain Section Methods: Sympathectomy Versus Sympathicotomy, Clipping, or Ramicotomy

Among the various nuances that have emerged over the course of the use of the thoracoscopic technique, a constant concern is the possibility of neural regeneration with recurrence of symptoms when the trunk is only cauterized (sympathicotomy) or there is no resection (as regularly in sympathectomy).

In the studies conducted to compare the two thoracoscopic procedures of sympathicotomy and sympathectomy for hyperhidrosis [15, 16, 20], Collin [15] reported recurrence in four of 54 patients treated by sympathectomy with scissors in the second rib within 9–12 months after the procedure; Kuda et al. [20] reported that there was no difference in recurrence between sympathicothomy and sympathectomy. In 2001, Bo-Young King et al., using what they called a "sympatheticotomy", but which can be interpreted as a “mixed technique”, did not observe recurrence during the follow-up period after sympatheticotomy: “We think that reinnervation with recurrence of symptoms [does not is] a problem of the procedure itself but a matter of technique and can be prevented by cephalic cauterization of the chain and cauterization of the caudal sympathetic chain after separation”.

To alleviate any doubt, Aydemir et al. [21] published a study in 2015, the objective of which was to evaluate and compare thoracoscopic sympathectomy and sympatheticotomy in the third level of ganglia (T3) for the treatment of primary palmar hyperhidrosis. In terms of initial surgical results, in relation to complications and satisfaction, the patient was followed up for 6 months postoperatively using a detailed interview and scored on a 1–3 scale (1 = very satisfied, 2 = satisfied and 3 = unsatisfied). In their results, no therapeutic failures occurred. The mean time of operation was 50 min for the sympathectomy group and 36 min for the sympatheticotomy group. Compensatory sweating occurred in 40 patients (89% for the sympathectomy group and 85.11% for the sympatheticotomy group). The satisfaction rate was 91.11% for the sympathectomy group and 93.61% for the sympatheticotomy group. Thus, there was no significant difference between thoracoscopic sympathectomy and sympatheticotomy of the third ganglion (T3) in the treatment of primary palmar hyperhidrosis in terms of initial surgical results, complications, and patient satisfaction.

To clarify whether sympatheticotomy is sufficient, Lin et al. in 2015 [22] carried out a prospective, randomized study with 200 patients. In this study, two groups of thoracic sympathectomy (R3) and thoracic sympatheticotomy were randomized plus racemic at the same level (R3+) (n = 100 each). Clinical observations were recorded over a 3-year follow-up period. The results showed that the curative rates of palmar and axillary hyperhidrosis were 100% for two groups. There was no statistically significant difference between the groups in the increase in left hand temperature after thoracic sympathetic nerve transection (3.6 ± 1.4 °C vs. 3.5 ± 1.3 °C), right hand increase (40% vs. 44%), recurrence rate (1% vs. 2%), and postoperative satisfaction rate (92% vs. 90%). However, the pain scores of the R3 group were significantly lower than those of the R3+group (3.0 ± 1.9 vs. 3.6 ± 1.9, $p < 0.05$).

Simple transection of the thoracic sympathetic chain is sufficient in the treatment of palmar hyperhidrosis, and there is no need for the ramicotomy.

The idea of the use of the ramicotomy only arose because of the possibility of denervation in a smaller area and, consequently, a lower rate of compensatory sweating. However, the study by Lee et al. [23] showed that although the rate of compensatory sweating with the use of the isolated ramicotomy is actually lower than in other methods, the patient satisfaction index is much worse with the use of isolated ramicotomy (around 67% vs. 90% with other methods). On the basis of these data the technique has practically been abandoned.

Another imagined form of sympatheticotomy is the use of chain clipping. Theoretically, this technique would be less invasive, have less postoperative pain, and provide the future possibility of reversion if the interruption of compensatory hyperhidrosis became a major factor.

The study conducted in 2015 by Hida et al. [24] compared the effects of sympatheticotomy by cutting or clamping on T3 in two outcomes—postoperative palmar transpiration and compensatory sweating—and also evaluated postoperative patient satisfaction.

They studied 289 patients undergoing sympathetic interruption bilaterally in T3 level for palmar hyperhidrosis. These patients were sent questionnaires by mail to assess the reported degree of postoperative palmar sweating and compensatory sweating, as well as their level of satisfaction. Of the 92 patients who responded to the questionnaire, 54 had been submitted to cut sympatheticotomy (cut group) and 38 by clamping (clipping group).

Sympathicotomy by T3 clamping was less effective in reducing the primary symptom of postoperative palmar sweating, but induced less compensatory sweating than cut sympathicotomy in T3. However, both methods were similar in relation to patient satisfaction. The degree of postoperative palmar sweating and the severity of compensatory sweating were inversely correlated with the degree of satisfaction of the patient.

Sympathic Chain Section Level

From the literature, we can observe some inferiority, when comparing sympathectomy without the need of ramicotomy. The use of the clipping was not as effective as the section of the chain, and the comparative postoperative between the two techniques is equivalent in terms of results.

With this in mind, the next question would be what level of the chain is most indicated to be sectioned, and to have an expected better outcome with lower indexes of compensatory sweating? Classically used levels were T2 and T3, or between these. The first study using the T4 level was performed by Lin in 2001 [25], with experience in 165 patients:

> Compensatory hyperhidrosis is one of the complications that surgeons strive to avoid. We have found that the preservation of the sympathetic chain to the head is the main influent factor to avoid reflex sweating in sympathicotomies; and with the sympathetic lower ganglion blocked, the sympathetic tonus for the head is preserved. T4 sympathetic block is an ideal procedure that can treat palmar and/or axillary hyperhidrosis and preserve most of the sympathetic tone to the head. We used sympathetic-T4 block in the treatment of 165 cases of palmar hyperhidrosis and axillary and we obtained excellent operative results without reflex sweating, from August 1, 2000 to February 28, 2001. We conclude that sympathetic-cotomy at the T4 level is the method that can treat the hand and axillary hyperhidrosis without inducing reflex sweating.

Following this line of reasoning, several other studies have been published with the same objective, and the vast majority of them corroborated Lin et al.'s conclusions, both in patient satisfaction index and in related complications: occurrence of compensatory hyperhidrosis is lower than following the use of higher chains, and even when present it is classified as "extremely uncomfortable" by only 3.2%. The satisfaction index for the surgery reaches an average of 94% and, incredibly (perhaps because of the compensatory hyperhidrosis being smaller), the remaining 6% who were not satisfied did not regret the operation [26].

Uniportal Versus Multiportal

Currently the most commonly used surgical technique for the sympathetic chain section is the anterior approach, with the patient sitting. Because it is a minimally invasive surgery and a non-malignant disease, the desire for favorable results, reduction of morbidity (mainly postoperative pain), and patient satisfaction became an obsession. In addition to these requirements, and since the vast majority of patients are young, aesthetic concerns are also a point of great interest.

Uniportal techniques (either with a single portal in the mammary furrow or in the third axillary space) have gained ground, and the choice varies depending on surgeon experience and patient preference. But would there be any gain with this technique?

Ibrahim and Allam [27] conducted a study comparing the two techniques (uniportal and multiportal) with 71 patients, of whom 35 were submitted to a multiportal technique and 36 to a uniportal technique. Preoperative, intraoperative, and postoperative variables were compared: morbidity, recurrence, and mortality.

The final results showed that the procedure was successful in 100% of patients; none presented recurrence of palmar hyperhidrosis, Horner's syndrome (oculomatous paralysis), severe postoperative complications, or death. There was no need for conversion to an open procedure.

In the postoperative period, with a multiportal technique, there was residual minimal pneumothorax in two patients (5.7%), while in the other group there was only one (2.8%). A minimum hemothorax occurred in one patient (2.9%) in the multiportal group and three patients (8.3%) in the uniportal group. Compensatory hyperhidrosis occurred in seven patients (20%) in the multiportal group and eight patients (22.2%) in the uniportal group.

With these results, the authors' conclusion was that no difference was found between the multi- and uniportal methods. Both are minimally invasive, effective, and safe procedures that permanently improve quality of life in patients with palmar hyperhidrosis.

Types of Energy

With the advent of technology applied to minimally invasive procedures, other forms of energy for tissue dissection and sectioning emerged with promises of lower postoperative pain, increased safety due to less heat dissipation in tissues, less neuromuscular stimulation, and less smoke in the operative field. These new forms of energy also entered our milieu and became a real option for procedures, among them sympathicotomy. But would the use of these new forms of energy make any difference in practice?

The 2015 Th2–Th4 study by Kuhajda et al. [28] was performed in 79 patients with palmar, axillary, or craniofacial hyperhidrosis. All patients were approached laterally, with 2 5 mm portals: the first in the medial axillary line, third space, and the second in the fifth space, posterior axillary line. The chain was sectioned on two, three, and four ribs bilaterally and ablated laterally the chain by 4–5 cm to section possible accessory branches. In the first 39 patients, section of the chain was performed with an electric scalpel and in the next 40 patients the harmonic scalpel was used.

In this study, no significant differences were found between the electric or harmonic scalpel. There was no significant difference between complications and severity of pain, with a slightly higher intensity of pain using harmonic scalpel ($p < 0.05$). Both provided adequate treatment for primary hyperhidrosis, although the electric scalpel had lower costs.

Besides the harmonic scalpel, there is another option for energy: ultrasonic. Divisi et al. [29] compared ultrasound scalpel section (ligature) and radiofrequency in terms of complications and effectiveness. A total of 130 sympathectomies were performed in 65 patients: electrocoagulation was performed in 20 procedures (15%), ultrasonic scalpel in 54 (42%), and radiofrequency dissection in 56 (43%).

Twelve complications (9%) were observed: thoracic pain in six patients (four with electrocoagulation, one with ultrasonic scalpel, and one with radiofrequency dissector); paresthesias in three patients with electrocoagulation; bradycardia in one ultrasound patient, normalized at the fourth postoperative hour; and unilateral relapse in two patients with electrocoagulation. Assessment of quality-adjusted life-years and quality of life revealed a statistically significant improvement ($p = 0.02$) in excessive sweating and general satisfaction after surgery, with Ultracision® and LigaSure™ showing better findings than electrocoagulation.

This study concluded that the latest-generation devices offered greater effectiveness in the treatment of hyperhidrosis, minimizing complications and facilitating the resumption of normal work and social activity of patients; however, they did not take into account that the satisfaction rates with the use of electrocoagulation are comparable to the new devices, as well as a lower cost with the former.

It is up to each surgeon to make a decision regarding device use, taking into account evidence-based medicine, patient satisfaction, and their own self-assurance with the use of these new devices.

Other Techniques Described

Transareolar Uniportal Thoracic Sympathectomy Under Intravenous Anesthesia Without Intubation

The transareolar uniportal thoracic sympathectomy under intravenous anesthesia without intubation technique was described by Chen et al. [30] in a randomized controlled trial, with the objective of evaluating its viability and safety. Endocópio was used in the pleural cavity, the insertion of which was made by an infrareolar incision of 2 mm and the patient was anesthetized and using laryngeal masks.

A total of 168 male patients underwent endoscopic uniportal thoracic sympathectomy, divided into groups A or B. Group A patients underwent a non-intubated transareolar technique (with laryngeal mask) with an endoscope and a 2 mm needle, and the patients in group B underwent intubated transaxillary sympathectomy with a 5 mm thoracoscope.

According to the results of this study, all procedures were performed without intercurrences, and the palms of all patients became dry and warm immediately after surgery. The mean recovery time was significantly lower in non-intubated patients. Postoperative sore throat occurred in four patients in group A and 32 patients in group B ($p < 0.01$). The mean length of the incision was significantly shorter in group A than in group B and the mean postoperative pain scores were markedly higher in group B than in group A. The mean cost of anesthesia was considerably lower in non-intubated than intubated patients and the mean cosmetic scores were higher in group A than in group B ($p < 0.01$).

Transumbilical Thoracic Sympathectomy

The transumbilical thoracic sympathectomy technique was described in a single-center trial of 148 cases with up to 4 years of follow-up [31]. In the reports of this transumbilical thoracic sympathectomy technique , an ultrafine flexible endoscope inserted into the umbilical region was used. After a 5 mm umbilical incision, the muscular region of the diaphragmatic dome was incised and the bronchoscope positioned in the thoracic cavity. The sympathetic chain was identified at the desired thoracic level and sectioned with electrocautery with the biopsy forceps.

This is the newest and largest study to date, and used a prospective database in the retrospective analysis of 148 patients (61 males, 87 females, mean age 21.3 years) operated on by the same surgeon in a single institution from April 2010 to March 2014. All procedures were performed under general anesthesia with intubation with double lumen endotracheal tube. The demographic, postoperative, and long-term data of the patients were recorded and statistical analyses were performed. All patients were followed up for at least 6 months after the procedure through clinical visits or telephone/e-mail interviews.

The procedure was successfully performed in 148 of 150 patients. Two patients had to be converted to a conventional thoracoscopic procedure because of severe pleural adhesions. The mean operative time was 43 min (range 39–107 min) and the mean postoperative time was 1 day (range 1–4 days). All patients were interviewed 6–48 months after surgery and no diaphragmatic hernia or syndrome was observed. The resolution rate of hyperhidrosis and axillary hyperhidrosis was 98% and 74.6%, respectively. Compensatory sweating was reported in 22.3% of patients. Almost all patients were satisfied with the surgical results and the cosmetic result of the incision.

It is suggested that this technique could avoid chronic pain and chest wall paresthesia associated with the thoracic incision, besides providing cosmetic benefits.

Subxiphoid Thoracic Sympathectomy

Subxiphoid thoracic access was reported by Chen et al. [32] in a single patient of 34 years old who underwent bilateral sympathectomy at the T3 level.

The patient was positioned in proclive (reverse "Trendelemburg"), anesthetized, and ventilated with selective intubation. Using a 2 cm incision in the subxiphoid region, the surgeon manually dissected a subcostal tunnel and, with his finger, entered the pleural cavity. An on-site Alexis and 10 mm optics were inserted.

After the strand was severed, the pneumothorax was removed with the probe and the patient did not need a drain. The operative time described was 60 min.

The author discusses whether this technique is better in relation to the transumbilical because the transumbilical needs a very long trocarter to reach the thoracic cavity, bringing risks to the patient. According to the author, the subxiphoid technique also does not cause intercostal pain to the patient postoperatively.

Unilateral Sympathectomy for Hyperhidrosis

According to the various authors who have published on the unilateral sympathectomy approach, among them Ravari and Rajabnejad [33], one of the first to publish the technique with a considerable number (52) of patients, videothoracoscopic surgery with sympathectomy on the “dominant” side of the patients’ symptoms would resolve bilateral hyperhidrosis.

In their series [33], from July 2010 to June 2013, 52 patients with primary palmar hyperhidrosis were submitted to unilateral video-assisted thoracoscopic sympathectomy for the dominant hand. Results were analyzed regarding the resolution of symptoms, occurrence of complications, rate of recurrence and compensatory hyperhidrosis, and need for surgery to the opposite side.

According to the authors, all patients were followed for 6–42 months. Palmar hyperhidrosis was completely relieved and absolute dryness was achieved in all patients in the same hand after the operation. Palmar hyperhidrosis in the opposite hand was cured until complete dryness in 24 (46.15%) patients. In 22 (42.3%) patients, there was no change in the opposite hand, but there was an increase in six (11.53%) patients. Only seven (13.46%) patients had to undergo contralateral sympathectomy. Compensatory hyperhidrosis occurred in 13 patients (25%) after unilateral sympathectomy. Five other patients (in total 18 [34.6%]) had compensatory hyperhidrosis after contralateral sympathectomy. It was mainly in the trunk in all 18 patients.

According to these authors, these numbers indicate that only a small number of patients will eventually need a contralateral sympathectomy in the non-dominant hand.

Prior Technical Design: Two Incisions

Anesthetic Induction

Patient will undergo general anesthesia with intubation oro-tracheally. The use of an oro-tracheal double lumen (broncocath) tube is optional; however, we see it as an advantage in most cases. If the single-track tube is chosen, the use of inhalation gases as a single anesthetic technique should be avoided, since the use of periods of apnea may lead to insufficient anesthesia.

Positioning

The patient is maintained in supine position until the end of anesthetic induction; having the anesthesiologist permission, the arms are positioned abductively—forming an angle of just over 90° relative to the trunk. The forearms are slightly flexed to avoid joint stress. Care should be taken at this time to avoid any distension to the brachial plexus structures. We also place a pillow under the patient's knees. After the positioning, the trunk is raised to a semi-seated position.

Incisions

We usually start the procedure on the left side, since we believe that after the left sympathectomy there may be a reduction in the heart rate, which is safer to evaluate soon after the beginning of the procedure—in the vast majority of cases, bradycardia is transient. We perform the first incision in the infra-mammary sulcus in females and in the areolar transition line in males. It is an incision approximately 6/7 mm to admit a 5 mm plastic disposable trocar. The subcutaneous tissue and musculature are crossed by blunt dissection using a pair of "Kelly" haemosthatics or "Metzenbaum" scissors —. On the moment of entering into the pleural space, it is ideal to have the lung collapsed by bolcking it or just putting the patient is in apnea. The trocar is then introduced through the previously dissected course. Via this trocar a 4 or 5 mm camera with 30° viewing angle is introduced.

The next incision, which is between 5 and 6 mm, is performed in the axilla, in the middle axillary line, inferior to the region of the local ones. A permanent 5 mm trocar will be introduced; it enters the pleural cavity under direct vision. The instrument of dissection is positioned in this trocar, usually by use of the harmonic scalpel or a hook coupled to the electrocautery.

Sympathectomy

We first perform the opening of the parietal pleura on both sides of the sympathetic chain, at the fourth and fifth rib height, following the pleural opening throughout the medial and lateral portion of the chain. After the pleural opening we are able to clearly visualize the sympathetic chain. We begin with the complete section of the upper portion of the chain, and then proceed with the section of the lower portion, which is carried out in the medial portion of the rib to avoid the vascular-nervous bundle. With the chain released, we start the fulguration—it must retract completely freely; if this does not happen, probably some branches were not completely released.

Pulmonary Expansion and Aspiration of the Residual Air

With the end of the sympathectomy, a nasogastric tube is introduced via the axillary trocar as a drain. The anterior trocar is withdrawn through the camera, holding it in position to observe complete lung expansion. The anesthetist re-inflates the lung, and the probe is connected to a vacuum system. The camera is removed after confirmation that the lung is lying against the chest wall. The anterior incision is closed with 4.0 monocryl wire at continuous points. After closing it is necessary to check if there is aerial fistula; this is done by introducing the probe/drain into a vat filled with water or saline. The anesthesiologist ventilates the lung and checks for bubbles; if there is no vent after the maneuver, the catheter is removed and the incision is closed as above.

References

1. Lakraj A-AD, Moghimi N, Jabbari B. Hyperhidrosis: anatomy, pathophysiology and treatment with emphasis on the role of botulinum toxins. Toxins (Basel). 2013;5:821–40. http://www.mdpi.com/journal/toxins
2. Sheski FD, Mathur PN, Finlay G, editors. Therapeutic uses of medical thoracoscopy therapeutic uses of medical thoracoscopy Page 2 of 5. Alphen aan den Rijn: UptoDate; 2013. p. 1–5.
3. Changizi M, Weber R, Kotecha R, Palazzo J. Are wet-induced wrinkled fingers primate rain treads? Brain Behav Evol. 2011;77(4):286–90.
4. Vretzakis G, Simeoforidou M, Stamoulis K, Bareka M. Supraventricular arrhythmias after thoracotomy: is there a role for autonomic imbalance? Anesthesiol Res Pract. 2013;2013:413985.
5. Cerfolio RJ, De Campos JRM, 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):1642–8. https://doi.org/10.1016/j.athoracsur.2011.01.105.
6. Ribas Milanez de Campos J, Kauffman P, Wolosker N, Munia MA, de Campos Werebe E, Andrade Filho LO, et al. Axillary hyperhidrosis: T3/T4 versus T4 thoracic sympathectomy in a series of 276 cases. J Laparoendosc Adv Surg Tech A. 2006;16(6):598–603. http://www.ncbi.nlm.nih.gov/pubmed/17243877

7. Licht PB, Pilegaard HK, Ladegaard L. Sympathicotomy for isolated facial blushing: a randomized clinical trial. Ann Thorac Surg. 2012;94(2):401–5. http://www.ncbi.nlm.nih.gov/pubmed/22633477
8. Weng W, Liu Y, Zhou J, Li H, Yang F, Jiang G, et al. Thoracoscopic indocyanine green near-infrared fluorescence for thoracic sympathetic ganglions. Ann Thorac Surg. 2016;101(6):2394. http://linkinghub.elsevier.com/retrieve/pii/S0003497516002149
9. Janszky I, Szedmák S, Istók R, Kopp M. Possible role of sweating in the pathophysiology of panic attacks. Int J Psychophysiol. 1997;27(3):249–52.
10. Méndez-Bértolo C, Moratti S, Toledano R, Lopez-Sosa F, Martínez-Alvarez R, Mah YH, et al. A fast pathway for fear in human amygdala. Nat Neurosci. 2016;19(8):1041–9. https://doi.org/10.1038/nn.4324
11. Wilder-Smith EPV. Water immersion wrinkling: physiology and use as an indicator of sympathetic function. Clin Auton Res. 2004;14(2):125–31.
12. Kim BY, Oh BS, Park YK, Jang WC, Suh HJ, Im YH. Microinvasive video-assisted thoracoscopic sympathicotomy for primary palmar hyperhidrosis. Am J Surg. 2001;181(6):540–2. /das/journal/view/36919996-2/N/12595072?ja=301839&PAGE=1.html&ANCHOR=top&source=
13. Kux M. Thoracic endoscopic sympathicotomy in palmar and axillary hyperhidrosis. Arch Surg. 1978;113:264–6.
14. Adar R, Kurchin A, Zweig A, et al. Palmar hyperhidrosis and its surgical treatment: a report of 100 cases. Ann Surg. 1977;186:34–41.
15. Collin J. Treating hyperhidrosis surgery and botulinum toxin are treatments of choice in severe cases. BMJ. 2000;320:1221–2.
16. Johannes Z, Martin I, Erik RH, et al. Video assistance reduces complication rate of thoracoscopic sympathicotomy for hyperhidrosis. Ann Thorac Surg. 1999;68:1177–81.
17. Haan J, Mckaay AJ, Cuesta M, Rauwerda J. Posterior approach for the simultaneous, bilateral thoracoscopic sympathectomy. J Am Coll Surg. 2001;192(3):418–20. /das/journal/view/36919996-3/N/11742608?ja=318620&PAGE=1.html&ANCHOR=top&source=MI
18. Fredman B, Olsfanger D, Jedeikin R. Thoracoscopic sympathectomy in the treatment of palmar hyperhidrosis anaesthetic implications. Br J Anaesth. 1997;79:113–9.
19. Kuhajda I, et al. Semi-Fowler vs. lateral decubitus position for thoracoscopic sympathectomy in treatment of primary focal hyperhidrosis. J Thorac Dis. 2015;7(S1):S5–S11.
20. Kuda T, Oshiro J, Nagamine N, et al. Comparison of thoracoscopic sympathectomy and sympathicotomy for primary palmar hyperhidrosis. Chest. 1998;114(suppl 4):S391–2.
21. Aydemir B, Imamoglu O, Ok T, Celik M. Sympathectomy versus sympathicotomy in palmar hyperhidrosis comparing T3 ablation. Thorac Cardiovasc Surg. 2015;63(8):715–9.
22. Lin M, Tu Y, Chen J, Li X, Lai F, Lin J. Efficacy comparison of two methods of r3 sympathicotomy for palmar hyperhidrosis. Zhonghua Yi Xue Za Zhi. 2014;94(47):3745–7.
23. Lee DY, Paik HC, Kim fazem H, Kim HW. Comparative analysis of T3 selective division of rami communicantes (ramicotomy) to T3 sympathetic clipping in treatment of palmar hyperhidrosis. Clin Auton Res. 2003;1:I45–7.
24. Hida K, Sakai T, Hayashi M, Tamagawa T, Abe Y. Sympathotomy para hiperhidrose palmar: os métodos de corte versus clamping. Clin Auton Res. 2015;25(5):271–6. https://doi.org/10.1007/s10286-015-0293-y. Epub 2015 14 de maio
25. Lin CC, Wu HH. T4-sympathetic endoscopic locking by clamping (ESB4) in the treatment of hyperhidrosis palmaris et axillaris - experiences of 165 cases. Ann Chir Gynaecol. 2001;90(3):167–9.
26. Choi BC, Lee YC. Sim SB. Treatment of palmar hyperhidrosis by endoscopic cut of the upper part of the sympathetic ganglion T4. Preliminary results. Clin Auton Res. 2003;Suppl 1:I48–51.
27. M I, Allam A. Comparing two methods of thoracoscopic sympathectomy for palmar hyperhidrosis. JAAPA. 2014;27(9):1–4.
28. Kuhajda I, Durie D, Koledin M, Ilic M. e cols. Electric vs. harmonic scalpel in treatment of primary focal hyperhidrosis with thoracoscopic sympathectomy. Ann Transl Med. 2015;3(15):211.

29. Divisi D, Di Leonardo G, De Vico A, Crisci R. Electrocautery versus Ultracision versus LigaSure in surgical management of hyperhidrosis. Thorac Cardiovasc Surg. 2015;63(8):729–34.
30. J C, Q D, M L, J L, X L, F L, Y T. Transareolar single port acute thoracic sympathectomy under intravenous anesthesia without intubation: a randomized controlled trial. J Laparoendosc Adv Surg Tech A. 2016;26(12):958–64.
31. Zhu LH, Chen W, Chen L, Yang S, Lu ZT. Transumbilical thoracic sympathectomy: a single-center trial of 148 cases with up to 4 years of follow-up. Eur J Cardiothorac Surg. 2016;49(Suppl 1):i79–83.
32. Chen JT, Liao CP, Chiang H, Wang B. Subxiphoid single-incision thoracoscopic bilateral ablative sympathectomy for hyperhidrosis. Interact Cardiovasc Thorac Surg. 2015;21:119–20.
33. H R, A R. Unilateral sympathectomy for primary palmar hyperhidrosis. Thorac Cardiovasc Surg. 2015;63(8):723–6.