Upper extremity sympathectomy

José Ribas Milanez de Campos[1], Paulo Kauffman[1], Carolina Brito Faustino[2], Nelson Wolosker[3,4,5]

[1]Disciplina de Cirurgia Torácica da Faculdade de Medicina da Universidade de São Paulo, São Paulo, Brazil; [2]Department of Vascular Surgery - Hospital Israelita Albert Einstein, Nelson Wolosker, São Paulo, Brazil; [3]Albert Einstein Medical School, New York, NY, USA; [4]Research and Innovation from Hospital Israelita Albert Einstein, São Paulo, Brazil; [5]Faculdade de Medicina da Universidade de São Paulo, São Paulo, Brazil

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Correspondence to: José Ribas Milanez de Campos. Disciplina de Cirurgia Torácica da Faculdade de Medicina da Universidade de São Paulo, Avenida Barao De Monte Mor, 341, Apto. 241, São Paulo 05687-010, Brazil. Email: jribas@usp.br.

Abstract: Hyperhidrosis is a condition in which there is excessive production of sweat that is disproportional to thermoregulation needs and that profoundly hampers the quality of life (QOL) of the population that is affected by it. The disorder is typically limited to the palms, the plantar and craniofacial regions, armpits, and manifests itself in a symmetrical fashion in addition to being associated to family history. At present, sympathectomy is considered the golden standard treatment and there are a number of approaches a surgeon may elect to adopt in its care. The clinical treatment with oxybutynin also improves screening of the group of patients that will benefit the most with this indication. However, the efficacy of the surgical method, what most counts for a successful outcome is the occurrence or not of compensatory hyperhidrosis whose intensity may impact the results. All patients are and must be thoroughly informed of this possibility prior to surgery. For the others indications, is also one of the final approaches necessary for a fruitful treatment.

Keywords: Sympathectomy; hyperhidrosis; video-assisted thoracic sympathectomy (VATS); excessive sweating; oxybutynin

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Introduction

Until the 1960s sympathetic system surgery, performed openly, was used predominantly to treat peripheral vascular diseases. With the advent of modern methods of revascularization of the limbs, the sympathectomy fell into disuse, being exceptionally used for this purpose. It was practically restricted to some patients with hyperhidrosis who accepted to take risks of surgery with relatively frequent side effects, such as Claude-Bernard-Horner syndrome, an aesthetically unpleasant situation, particularly in females.

Although Kux published a large number of patients submitted to endoscopic sympathectomy in 1954 and reported good results, for unknown reasons the technique was not recognized and was forgotten for almost 30 years (1).

With the recent advances in the optical, video and instrumental systems for endoscopic surgical procedures, it has become possible to perform cervicothoracic sympathectomy by videothoracoscopic technique, less invasive and better accepted by the patients. In the 1980s several surgeons used the endoscopic technique to perform this procedure, and in the 1990s many studies appeared in the literature, mainly from Europe, Asia and Israel (2).

From 1995 we began to perform videothoracoscopic thoracic sympathectomy to treat primarily hyperhidrosis patients. With this minimally invasive technique, thousands of surgeries were performed worldwide, which brought

technical improvements and excellent results (3).

In this review, we present the main current conducts and results in situations that use the thoracoscopic video sympathectomy.

Indications for thoracic sympathectomy

Current indications for thoracic sympathectomy are limited to primary hyperhidrosis and selected cases of chronic ischemia of the hand, regional complex regional pain syndrome (CRPS) (4), long QT syndrome refractory to clinical treatment (5) and Raynaud's syndrome (6).

Essential hyperhidrosis

Essential or idiopathic hyperhidrosis is the production of excessive amount of sweat beyond what is necessary for the needs of thermoregulation of the body. Causal mechanism is not known (7).

Hyperhidrosis is limited to the palms of the hands, soles of the feet or armpits in a symmetrical way. It can also affect the craniofacial segment. Hyperhidrosis may occur during childhood but is more intense during adolescence (8).

Hyperhidrosis affects approximately 3% of the population and in 13% to 57% of patients it may be associated with a family history of hyperhidrosis (9).

Clinical treatment has to be attempted initially in all cases of hyperhidrosis (HH). However, it requires constant adherence by the patient. Topical agents, botulinum toxin and iontophoresis are clinical alternatives that have shown poor effectiveness and with a short time action. The most effective clinical treatments are the use of oxybutynin (10), glycopyrrolate (11) and botulinum toxin (10,12-14).

Sympathectomy is indicated in patients who do not show improvement in quality of life (QOL) despite adequate clinical treatment and in those who are willing to accept the risks involved in the surgical treatment (15).

Ischemia of the hand

Some patients with ischemia of the hand (thromboangiitis obliterans and distal arterial obstructions, ulcers in the fingers, or ischemic pain) may benefit from sympathectomy (16,17).

Complex regional pain syndrome (CRPS)

CRPS, is a disproportionate regional pain condition that occurs after injury, and associated with signs of vasomotor dysfunction and sudomotor activity that often results in impairment of motor function.

Sympathectomy is an alternative in patients who do not present good results with nonsurgical treatment or in patients who have transient benefit from pharmacologic sympathetic blockade (18).

Long QT syndrome

It is an idiopathic congenital disorder characterized by a lengthened QT interval on the electrocardiogram. These patients frequently present severe tachyarrhythmia, syncope, and sudden death. Sympathectomy is only indicated in patients who, even with appropriate clinical treatment, continue to have syncopal crises (about 20% to 25% of the patients) (19).

Raynaud's syndrome

Raynaud's syndrome results in episodic spasm of arterioles in the digits, associated with pallor or cyanosis, usually precipitated by exposure to cold or drugs. Sympathectomy is indicated in patients who despite adequate clinical treatment present trophic lesions that do not heal (20).

Video-assisted thoracic sympathectomy (VATS)

Surgical technique

Until the 1990s, open surgery was the gold standard for cervic-thoracic sympathectomy. Nowadays, the open technique is only indicated when VATS cannot be accomplished because of technical reasons and we can consider an extreme rare situation. The advantages of video-assisted surgery over other conventional open thoracotomy procedures could be resumed as: the accurate vision of the surgical field, better identification of the intrathoracic anatomy, low morbidity, cosmetic results, low cost and short hospital stay (21).

Even in children, VATS has been used in daily practice, apparently with the same safety and good results as adults. It is also known the great value of surgery performed on children younger than 14.

Nowadays, VATS is considered the gold standard for thoracic sympathectomy. In video thoracic surgery, many different approaches can be used (2 ports, 3 ports, 4 ports, lateral, dorsal, etc.), each with their positive and negative

values. In our service, we use an easy and practical technique based on the use of two ports (22).

Instrumentation

It is necessary to use the 30o-angle thoracoscope, a video camera with monitor and recorder, a light source, video endoscopic instruments, an electrocautery (harmonic or electric), and in specific cases clips.

Anesthesia

We use a double-lumen endotracheal general anesthesia, enabling stop of the patient's ventilation and collapsing the lung on the side that will be sympathectomized. If necessary, bronchoscopy should be used to verify the tube positioning. Selective intubation is occasionally used in patients undergoing resection of the fourth ganglion or with a previous history of pleural diseases, lung infections/surgeries and/or empyema's. When the procedure is performed in the higher ganglia, the simple lumen tube may be used in combination with adequate control over lung ventilation.

Positioning of the patient

The patients are placed in dorsal decubitus, in a semi-seated position with the trunk raised at approximately 45°. Two small pads are placed under the shoulders to create a space between the axillae and the surgical table and to bring the shoulders forward, thereby avoiding distension of the brachial plexus when the arms are positioned at 90º abduction on the arm rests. Another pad under the knees and a securing strap at the hip level allow the legs to be comfortably positioned, impeding the patient's movements on the surgical table when the table is laterally rotated to bring forward the sites for the operation (right or left).

Technique

The first of the incisions is made on the anterior axillary line at the level of the fourth or fifth intercostal space in order to introduce a camera. The second incision at the second intercostal space on the medial axillary line is used to introduce the surgical instruments, electric or harmonic scalpel, scissors, dissecting forceps, retractable hook, and aspirator into the pleural cavity. In cases where we found adhesions and or some technical difficulties, to make the dissection easier, a third mini-incision is made. Trocars of 5.5 mm diameter are introduced into all the incisions to keep the pathway open and protect the structures of the thoracic wall. Carbon dioxide insufflation into the pleural cavity could be used but in the majority of the procedures we have used open pneumothorax, which has proven to be adequate. The sympathetic chain is identified through the parietal pleura, and the chain is sectioned above the costal arches and the target segment isolated is cauterized. Application of vascular clips to the main sympathetic trunk, instead of thermoablation, is sometimes an alternative. After revision of the hemostasis, a 14 Fr aspiration probe is placed through the upper trocar and connected to a negative-pressure aspirator. The anesthetist is then asked to ventilate the collapsed lung until complete expansion has been achieved. The corresponding incision is sutured, and occlusive bandages are left on the surgical incisions for 24 hours. In the post-anesthesia recovery room, chest radiography is requested in order to observe the expandability of the lung.

Another alternative used today in our group is the uniportal approach. It allows all the benefits described above and the surgery is performed through to 1–2 cm, just one port access (21,23).

Another technical improvement, a simple and useful tool is nowadays evaluable in the majority of our hospitals. The pulse oximetry-derived perfusion index (PI) quantifies pulsatile blood flow at the oximeter. Thoracic sympathectomy increases blood flow; thus, we postulate it will reliably increase PI. The paper published by Jeng *et al.* evaluated the ipsilateral finger PI as a predictor of successful sympathectomy during the procedure. They defined a successful sympathectomy by at least a 50% increase on the ipsilateral arm. The hemodynamics remained constant throughout the study period. All patients had postoperative resolution of their hyperhidrosis symptoms. In the conclusions they found that intraoperative PI derived from an ipsilateral finger pulse oximeter is an intraoperative marker for successful thoracic sympathectomy (24).

A different approach is the use of the sympathectomy performed in two stages. First one side and later, if necessary, the other side. In this type of approach, compensatory sweating seems to be less intense than bilateral sympathectomy in a single stage (25).

Technical difficulties in VATS

Pleural adhesions (3% to 7%) are the most frequently

found. Generally they are weak and are easy to be released. In some occasions they are firm and extensive, caused by previous pleuropulmonary diseases, making sympathectomy impossible. The pleural adhesions can not be diagnosed preoperatively by any radiological exam (26).

Azygos lobe is a rare anatomic variation that involves an accessory pulmonary lobe at the apex of the lung, making it difficult or sometimes impossible to carry out VATS (27). Preoperative chest radiography may identify this anomaly (22).

Technical alternatives for VATS

Interruption of the chain without the removal of ganglia (sympathicotomy) is a good alternative to ganglia resection. It is a technique that can be eventually reversed until 10 days after the intervention (28,29).

Alternatives to sympathectomy are sympathicotomy and thoracoscopic clipping. The results are similar to those of sympathectomy. Sympathectomy using embryonic natural orifices, the transumbilical endoscopic surgery with a flexible endoscope is a nove procedure that eventually can reduce postoperative pain (30).

Contraindications for VATS

The current contraindications to VATS are: Lung infections that can evolve with pleural effusion and require puncture or drainage, dense pleural adhesions caused by lung diseases as tuberculosis, previous thoracic surgeries, thoracic radiotherapy, sinus bradycardia, clinical situations leading to contraindication to endotracheal anesthesia and obesity (31).

Complications of VATS

Significant intraoperative hemorrhage is rare, mostly originating from intercostal vein disruptions during dissection of the sympathetic chain. It may also occur at the trocar insertion site. Chylothorax is an extremely rare complication resulting from in the laceration of the accessory thoracic duct. The most common perioperative complication is pneumothorax; however, thoracic drainage is only necessary in a small number of them (0.4% to 2.3%). It results from direct injury to the lung at the time of trocar insertion or tearing of an apical adhesion when the lung is depressed. It is important to carry out chest radiography during the immediate postoperative period to rule out the possibility of significant pneumothorax, since, in this situation, pleural drainage has to be performed, usually for 24 hours.

Pulmonary atelectasis occurs occasionally, especially in the upper right lobe (1.2% of the patients). The treatment is respiratory physiotherapy. Transitory bradycardia during sympathectomy occurs rarely in these patients, but recovery is observed after a few minutes of clinical observation. Caution is necessary in patients that already present previous bradycardia. Severe postoperative pain is not a common event. Most patients report acute pain, especially when breathing in deeply, for some hours after the operation, but a significant number of them complain of pain of lower intensity that is more constant in the dorsal region, which may occasionally require analgesics for some days.

Paresis and paresthesia in the upper limbs was observed rarely due to the patient's position on the surgical table, which caused distension of the brachial plexus. In most patients, these manifestations regressed within 3 days to 3 weeks. Some authors have reported neuralgia in the internal region of the arm, which usually disappears after the first 6 weeks. Horner's syndrome is a side effect from complete sympathetic denervation of the upper limb when the stellate or G2, are resected. However, in cases of hyperhidrosis in which nowadays only G3 or G4 are manipulated, this complication is considered extremely rare (32).

Target ganglia

The level and the extension of sympathectomy is an important subject (33). For the treatment of hyperhidrosis, the best therapeutic results are being achieved when sympathectomy is performed at lower levels (G3 and G4 ganglia) leading to a significant reduction in the complications: Horner's syndrome and compensatory hyperhidrosis.

Palmar hyperhidrosis

At the beginning of the decade of 2000 we used to resect G2 and G3 ganglia with good results in terms of anhydrosis; however, it was a challenging procedure and was associated with a high incidence of Horner's syndrome and severe compensatory hyperhidrosis, (more than 75% of the cases) because a very extensive area including the cephalic, cervical, and upper limb segments is denervated. This collateral effect has been responsible for dissatisfaction of a lot of patients. To minimize this inconvenience, thermoablation

of G2 was initially replaced by thermoablation of G3, and nowadays several authors recommended by G4, leading to similar results in palmar anhydrosis, but considerably lowering the compensatory hyperhidrosis. This is probably due to preservation of the sympathetic tonus for the cephalic segment. In our personal experience patients submitted to G3 ablation usually present totally dry hands and need to use skin moisturizers while patients submitted to T4 ablation present continued low levels of sweating (not hyperhidrosis but a little greater than normal physiological levels), what is considered to be therapeutic successes. Other alternatives are sympathicotomy (without the removal of ganglia) and or blockade by endoscopic clipping (34).

In another recent paper, Zhang *et al.* intended to determine the optimal denervation level for thoracic sympathectomy by comparing the efficacy of G3 versus G4. They searched of 2,201 articles reviewed, 10 (G3 group, 566 patients; G4 group, 629 patients) were selected. G4 was associated with a lower incidence of postoperative compensatory sweating, dry hands, and gustatory sweating than G3. No significant difference in symptom resolution or patient satisfaction was found between groups. They concluded that G4 may be superior to G3 in patients with palmar symptoms. However, this finding should be validated in high-quality, large-scale randomized controlled trials (35).

Sang *et al.*, published a systematic review, where they investigated the appropriate level of sympathectomy for palmar hyperhidrosis using a computerized systematic literature search using PubMed and EMBASE from January 1990 to July 2016. A total of 4,075 citations were identified, of which 91 were eligible for inclusion, including 68 observational studies and 23 comparative trials. We have the same opinion and results that was written in the conclusion of these paper, generally, lowering the level and limiting the extent of sympathectomy could reduce the incidence of complications. They also concluded that "*cumulative data from more than 13,000 patients suggest that ETS is a safe, effective, and reproducible procedure with a high degree of patient satisfaction. Currently available evidence suggests that G2-free sympathectomy may reduce the incidence of compensatory hyperhidrosis without compromising success rates and safety*" (33).

The results of VATS in children was unknown until 2010. Neves *et al.* have investigated the improvement in QOL of a group of 45 children who did and did not undergo sympathectomy for the treatment of palmar hyperhidrosis 4 years after the initial evaluation. Forty-five children with palmar symptoms were initially evaluated. Children were divided into two groups: 30 in the surgical group and 15 in the control group. We studied the evolution of palmar hyperhidrosis, negative effect of hyperhidrosis on the QOL before the treatment, and improvement in QOL after treatment. Twenty-five patients (83.4%) in the surgical group experienced great improvement, and five (16.6%) experienced partial improvement. Two (13.3%) children in the control group and 23 (76.7%) in the surgical group had great improvement in QOL. In conclusion they found that for children with palmar symptoms and poor QOL, surgery is better than no treatment (36).

Almost the same experience in the surgical treatment of primary focal hyperhidrosis of the hands by thoracoscopic bilateral G3 sympathectomy in pediatric patients, published by Lage *et al.* with the mean age of 14 [6–21] years. All patients had previously tried at least one form of medical therapy with no success. All patients were extensively counseled regarding the potential side effects of the sympathectomy. Also, they found the same conclusion that G3 sympathectomy is a safe and effective treatment for children and adolescents with primary focal hyperhidrosis of the hands who failed medical management and have a very low rate of compensatory sweating (37).

Axillary hyperhidrosis

Resection of the second to the fourth ganglia of the thoracic sympathetic chain was the first step in treating this condition. It was replaced by thermoablation on G3 and G4 and nowadays by single G4 thermoablation, resulting in excellent therapeutic success (anhydrosis), less severe compensatory hyperhidrosis, and a higher satisfaction rate. QOL in both levels was equally improved after 1 and 6 months of follow-up. Other alternatives are sympathicotomy and blockade by endoscopic clipping (38).

Axillary hyperhidrosis is a condition that has a great impact on affected individuals' QOL. Standardization of the technique includes section of the sympathetic trunk at different levels, according to the site of symptoms. The aim of this contemporary review conducted by Felisberto Júnior *et al.*, a Brazilian group, is to evaluate the efficacy of thoracic sympathectomy through a systematic literature review comparing sympathectomy at different levels of the sympathetic chain. Despite the small number of studies available, the meta-analysis has shown that for palmar, lower sections of the sympathetic chain are as effective as high ones for symptoms control or remission but display lower rates of compensatory sweating. With the focus on

axillary hyperhidrosis, procedures done at lower levels are also more effective and have lower rates of compensatory sweating. Thus, low resections, based on data from the current literature, are the best options for the treatment of axillary and palmar PH, with good satisfaction rates and improvement of patients' QOL (39).

Craniofacial hyperhidrosis or facial rubor

Sympathetic denervation of the face and head can be obtained with thermoablation including the G2 ganglion. Craniofacial hyperhidrosis may lead patients to a significantly impaired QOL. Surgical treatment in our opinion is reserved for more severe cases refractory to common first-line agents. The aim of this study conduct recently by Wolosker *et al.* was to evaluate the efficacy of surgery and to compare the results between patients with facial hyperhidrosis as main complaint and patients with facial hyperhidrosis as non-main complaint. In conclusion they found that "*despite the greater improvement in hyperhidrosis symptoms*, *experienced lower improvement in QOL. Compensatory hyperhidrosis (CH) was the most frequent side effect*, *affecting more than 92% of the patients*. *Sympathetic blockade of isolated G3 are advocated for some authors and also using clips is an alternative treatment for these patients*."

We really have two thinks twice or more when looking a facial hyperhidrosis who may lead patients to a significantly impaired QOL. Sympathectomy is reserved for more severe cases and or refractory. The aim of the study published by Fukuda *et al.* was to evaluate the efficacy of VATS for facial hyperhidrosis and to compare the results between patients with facial hyperhidrosis as main complaint and patients with hyperhidrosis in other sites. This was a retrospective study based on medical chart analysis according to the main site of complaint. We assessed improvement in QOL, improvement in hyperhidrosis, and presence of complications and side effects, notably compensatory hyperhidrosis. In the conclusions, patients with facial main complaint, despite the greater improvement, experienced lower improvement in QOL compared to patients with other sites. Compensatory hyperhidrosis was the most frequent side effect in both groups, affecting greater number of the patients (40).

This paper specifically about facial blushing, published by Girish *et al.* aims to review the evidence to support the effectiveness of sympathectomy as a treatment for facial blushing in terms of relief of the symptoms, patient satisfaction, recurrence of blushing, patients regretting treatment and its associated complications. Nine studies met the inclusion criteria with 1,369 patients included in the final analysis. The age range of patients was 8 to 74 years, with 56% females. Mean follow-up was 21 months. The pooled proportion of patients who had good relief of facial blushing was 78.30%, complete satisfaction was reported in 84.02% and compensatory sweating and gustatory sweating were the commonest complications occurring in 74.18% and 24.42% respectively. The estimated proportion of patients regretting surgery was 6.79%. In conclusion interruption at T2 or T2–3 ganglia appears to be an effective treatment for facial blushing. However, lack of randomized trials comparing sympathetic interruption with non-surgical methods of treatment and heterogeneity of included studies with respect to assessment of outcome measures preclude strong evidence and definitive recommendations (41).

Complex regional pain syndrome, vascular disease, and Raynaud's syndrome

Also known as causalgia, reflex sympathetic dystrophy (RSD), post-traumatic pain syndrome, shoulder-hand syndrome, and Sudeck's atrophy, is a term that has been used since 1994. It describes a regional pain condition that often occurs after injury, is disproportionate to the inciting event and is associated with signs of vasomotor dysfunction and sudomotor activity. It often results in impairment of motor function. After months there is increased pain, and sensory dysfunction and motor, or trophic changes (or both) develop (dystrophic stage). Treatment includes physical therapy (indispensable), psychotherapy, pharmacologic therapy and surgical therapy. The key to success is starting in the early stages of the disease process. Sympathetic blockade using local anesthetic has been used to control pain in selected patients. If it is effective, this technique can be repeated, together with physical therapy to recover functionality of the limb. In these specific group of patients, sympathectomy can be used with success. The same technique described before, a unilateral sympathectomy from inferior 1/3 of stellate ganglia and G2, G3, G4 is the target (42).

Long QT syndrome

An idiopathic congenital disorder characterized by a lengthened QT interval on electrocardiograms and associated with a high incidence of severe tachyarrhythmia,

syncope, and sudden death. The young age of most of these patients and the high morbidity and mortality in untreated individuals have led to a search for effective therapies. Severe episodes typically occur during intense physical exercise or emotional crises, which leads to the supposition that the sympathetic nervous system plays an active part in the genesis of the problem. Beta-blockers are effective in preventing such crises in 75% to 80% of the cases. Sympathectomy is only potentially indicated in patients who even with appropriate clinical treatment continue to have syncopal crises. The same technique described before, a unilateral sympathectomy from inferior 1/3 of stellate ganglia and G2, G3, G4 is the target (43).

Latest publications and multiple case studies have suggested that sympathectomy reduces the occurrence and frequency of symptoms in long QT syndrome. Surman *et al.* published a literature review to report on the short- and long-term outcomes of this procedure. In the conclusion the authors report that typically resulting in reduction in symptoms but increasing the risk of Horner's syndrome and intermittent temperature changes. Short-term follow-up a G2–G5 sympathectomy revealed reduction in symptoms, no more requirements for beta blocker therapy and reduced QT interval. We now believe that further follow-up using greater patient numbers will support this target area to sympathectomy as an option for surgical management of long QT syndrome (44).

Raynaud's disease and phenomenon of Raynaud

Characterized by episodic spasm of arterioles, usually in the digits, with intermittent pallor or cyanosis, and are precipitated by exposure to cold, emotional upset, or drugs. Raynaud's disease, most common in young women, is idiopathic. Raynaud's phenomenon is secondary to other conditions such as connective tissue disorders, blood diseases, neurological disorders, obstructive arterial diseases, trauma, drug intoxications (ergot), dysproteinemias, and primary pulmonary hypertension.

During the crisis, patients may complain of pain, hypothermia, numbness, and paresthesia in the affected fingers. When these episodes are frequent and intense, they may cause obstruction of arteries in the fingers and palms that subsequently result in ischemic lesions in the fingers, which are very painful and resistant to healing. The treatment for Raynaud's syndrome is essentially nonoperative. Sympathectomy has been used in rare patients that despite adequate clinical treatment continue to have severe symptoms or trophic lesions that heal with difficulty. In all these indications the target ganglia are the same level with the unilateral procedure (45).

Different authors including ourselves, Karapolat *et al.* aimed at demonstrating experiences with endoscopic thoracic sympathectomy in the treatment of Raynaud's disease. Endoscopic thoracic sympathectomy should be considered an ultimate choice for patients with Raynaud's disease who have treatment-resistant severe symptoms and serious complications, disturbed social and daily lives, and impaired QOL, and all patients should be properly informed before the surgery about the possibility of a high rate of recurrence, and the symptoms could have returned to their preoperative levels in 66.6% of the patients at 6 months (46).

Results

Most patients who undergo surgery for PH in adulthood are female, and the children's group in this study were also predominantly female, probably because excessive sweating has greater repercussions in a girl's day-to-day life. The results in patients with hyperhidrosis have been uniformly very good. The immediate postoperative period is uneventful in almost 95% of the patients, permitting these individuals to be discharged on the following day or even on the same day. The success rate in the abolition of hyperhidrosis (i.e., anhydrosis) for palmar hyperhidrosis is very high, ranging from 87% to 100%. In addition to traditional outcome data (anhydrosis and subjective satisfaction), QOL analyses are also being used in the evaluation of patients.

Recurrence of the symptoms has been reported in 1% to 13% of operated patients. The main cause of the recurrence is technical failure. Reoperation is usually successful. One adverse effect from sympathectomy is gustatory sudoresis. It is unrelated to the level of the sympathetic chain blockade, and its incidence is very variable and is probably related to eating habits in different regions, ranging from 5.5% to 31.9%. In most cases, it is of light to moderate intensity and does not interfere with QOL.

CH consists of an increase in the severity of sweating in locations that were previously normal. This is the most frequent and most feared side effect from thoracic sympathectomy. The reported rates of CH are higher than 75% and when severe are considered the mains cause of patient dissatisfaction. It occurs mainly on the abdomen, back, and thighs, and it becomes more uncomfortable

on hot days, during physical exercise, and in hot work environments. It may diminish over time, or the patient may learn to live with it. Compensatory hyperhidrosis has a high correlation with the level of resection, and the extent of resection. The higher the interruption or resection of the sympathetic chain, the more afferent fibers responsible for the inhibition of sweating would be harmed, therefore causing a considerable increase in the quantity and intensity of CH. Another risk factor for CH is a high body mass index. Obese patients should not to be operated on. The rate of compensatory hyperhidrosis and its severity is tolerated better by children, and their postoperative satisfaction is higher than that of adolescents and adults. Due to the importance of CH, it is necessary to alert all patients with hyperhidrosis to this risk before they choose sympathetic denervation or an alternative technique.

According Vannucci *et al.* published in a recent paper with a Brazilian experience, "*primary hyperhidrosis is*, *by far*, *the main indication for thoracic sympathectomy and this procedure is usually carried out thoracoscopically with excellent results*. *However*, *until today*, *hyperhidrosis is a part of thoracic surgery still surrounded by controversy*, *persisting as an open field over which some confusion still resides regarding its pathophysiology*, *terms definitions and operative approaches*". In the Brazilian literature this one of the most complete recommendations to provide for all the readers a wide but easily comprehensible review of the theme, discussing and clarifying the major concepts with respect to its clinical presentation, available treatment options and strategies with their potential benefits and risks, also the adequate patient selection, as well as the clinical results (47).

Do Method and Level Matter and the mean follow-up time of the patient satisfaction maintain with the time? Trying to answer these two questions the following papers published by Cheng *et al.* with a retrospective medical chart review with patients who underwent thoracoscopic intervention were mailed questionnaires regarding their presenting and postoperative symptoms and satisfaction 6 months to 15 years after their procedure. Most patients reported relief of their symptoms and were satisfied with surgical intervention, regardless of method used. Although postoperative compensatory hyperhidrosis was common, this did not appear to affect overall patient satisfaction. The inclusion of rib level G2 ganglion resulted in a significantly increased incidence of compensatory hyperhidrosis (48).

In addition, the second author Raposio *et al.* evaluated if and how this procedure improves the QOL in patients after a mean follow-up of 9.5 years. Questionnaires were submitted to randomized patients, both to evaluate the durability of the results and to assess their QOL after surgery. In conclusion according to the data obtained, the procedure was described significantly improves in the QOL of treated patients, also proving the durability of this procedure (49).

Causes of failure

Incomplete denervation

Late activation of the intermediate ganglia, (microscopic aggregates of ganglion cells distributed in the communicating branches or even in the anterior roots of the cervical and brachial spinal nerves) could explain failures in the sympathetic denervation of the upper limbs. Despite this high success rate, some patients are unresponsive and eventually need a resympathectomy. Few studies have previously analyzed exclusively the results of these resympathectomies and none have objectively evaluated the degree of response to surgery or the improvement in QOL. De Campos *et al.* recently published a retrospective study, evaluating 15 patients from an initial group of 2,300 patients who underwent resympathectomy after failure of the primary surgical treatment and in the conclusion they founded that no major complications occurred; the presence of adhesions was reported in 11 patients and pleural drainage was necessary in 4 and resympathectomy is an effective procedure, improves the QOL in patients who failed after the first surgery (50).

Regeneration

There is no evidence of regeneration of the sympathetic ganglion cells. However, if only the axis cylinder is sectioned, regeneration of new fibers may take place from the ganglion cell. This may have a negligible effect in operations in which the paravertebral ganglia are removed.

Functional reorganization (collateral nerve sprouting)

Degenerated fibers produce humoral substances that stimulate close intact nerves to establish connections with denervated ganglion cells. Hence, cutting only the preganglionic fibers responsible for the innervation of the upper limbs (the fibers that pass by the stellate ganglion on their pathway to the superior cervical ganglion) would give rise to favorable conditions in the stellate ganglion for sprouting. Furthermore, there may be a functional connection between these branches and the ganglion cells

present in the spinal nerves, which would explain the return of sympathetic activity in the limb.

Reversibility

Some authors wrote that the widespread use of endoscopic thoracic sympathectomy is an effective treatment of primary hyperhidrosis with the major limitation is the side effect of compensatory sweating severe enough that patients request reversal. When the procedure was done with clips, reversal is a "simple" thoracoscopic outpatient procedure of removing the clips. Despite, subsequent reversal of the sympathectomy, i.e., nerve regeneration, is successful in many cases reported. However, until today the follow-up of all these reports is very short and not proved yet. Factors contributing to success rates require further study (51).

Controversial paper also published by Kocher *et al.* with a study to compare the two currently most commonly used methods for thoracic sympathicotomy: transection and clipping. A retrospective study on a total of 63 patients, who underwent rib-oriented sympathicotomy, either by transection or by clipping. Their results confirm that clipping is at least as effective as transection of the sympathetic chain in the treatment of hyperhidrosis and facial blushing. Furthermore, the analysis of all larger studies on unclipping in humans shows a surprisingly high reported reversal rate between 48% and 77% (52).

To close our comments about that subject, the surgical techniques used and the levels of targeting the sympathetic chain vary tremendously. Most surgeons transect or resect the sympathetic chain, but application of a metal clip that blocks transmission of nerve impulses in the sympathetic chain is used increasingly worldwide. This approach offers potential reversibility if patients regret surgery, but the question of reversibility remains controversial. In the conclusions the authors like Thomsen *et al.* founded that conventional and immunohistochemical stains confirmed that application of metal clips to the sympathetic chain caused severe histological damage in the sympathetic trunk that remained visible 4 weeks after clip removal experimentally. However, after 12 weeks, these signs of damage had clearly decreased, which suggests in theory that application of metal clips to the sympathetic chain is a reversible procedure if only the observation period is prolonged. Further studies in humans with longer periods between application and removal as well as investigations of nerve conduction should be encouraged because we do not know whether histological reversibility at cellular level translates into physiological reversibility and possible correlation of nerve trauma with the duration of the applied clip (53).

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Footnote

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