Arch Bronconeumol. 2011;**47(2)**:94-102

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SEPAR Guidelines

# Guidelines on Surgery of the Thoracic Sympathetic Nervous System

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ARTICLE INFO

*Article history:*
Received May 27, 2010
Accepted May 29, 2010

*Keywords:*
Thoracic sympathectomy
Hyperhidrosis
Facial flushing
Video-assisted thoracoscopy
Side effects
Compensatory sweating
Clipping
Guidelines
Thoracic surgery

ABSTRACT

Thoracic sympathetic nervous system (SNS) surgery has increased in importance in recent years, generating great expectations among the general population and the scientific community. This has been due to the excellent results obtained by video-assisted thoracic sympathectomy in the treatment of essential hyperhidrosis and other thoracic SNS disorders.

This minimally invasive surgical technique has been shown to be effective and to have low morbidity. It is accepted as one of the best therapeutic options for the treatment of palmar and bilateral axillary hyperhidrosis, and the number of patients interested in undergoing the procedure has increased considerably.

Although compensatory sweating, which is occasionally intense, often occurs after the surgery, this and other side effects of the technique are well tolerated by patients.

The current evidence on thoracic SNS and the treatment of essential hyperhidrosis is based on observational studies, making it difficult to compare series and draw conclusions. There has been much discussion on standardizing the technique, defining the most favorable levels for clipping, and choosing the type of denervation with the least amount of side effects. This has led to the need to draw up these guidelines which should clarify and standardize the criteria for managing patients with thoracic SNS disorders.



## Normativa sobre Cirugía del Sistema Nervioso Simpático Torácico

*Palabras clave:*
Simpatectomía torácica
Hiperhidrosis
Rubor facial
Videotoracoscopia
Efectos secundarios
Sudoración compensadora
*Clipping*
Normativa
Cirugía torácica

RESUMEN

La cirugía del sistema nervioso simpático torácico (SNST) ha experimentado un gran auge en los últimos años, generando gran expectación entre la población general y la comunidad científica. Esto se ha debido a los excelentes resultados que ha obtenido la simpatectomía torácica por videotoracoscopia en el tratamiento de la hiperhidrosis esencial y en otros trastornos del SNST.

Esta técnica de cirugía mínimamente invasiva ha demostrado ser efectiva y con baja morbilidad, aceptada como una de las mejores opciones terapéuticas para el tratamiento de la hiperhidrosis palmar y axilar bilateral, viéndose incrementado de manera considerable el número de pacientes que consultan con intención de operarse.

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0300-2896/$ - see front matter 

Aunque la sudoración compensadora, intensa en ocasiones, aparece con gran frecuencia tras la cirugía, éste y otros efectos secundarios de la técnica son bien tolerados por los pacientes.

La evidencia actual respecto a la cirugía del SNST y del tratamiento de la hiperhidrosis esencial se basa en estudios observacionales, haciendo difícil comparar series y extraer conclusiones. Se ha discutido mucho para unificar la técnica, definir los niveles de sección más favorables y elegir el tipo de denervación con menos efectos secundarios. Este hecho crea la necesidad de elaborar esta normativa que clarifique y unifique criterios para el manejo de los pacientes con trastornos del SNST.



## Introduction

Surgery of the thoracic sympathetic nervous system (SNS) is not a new procedure. It has been performed since the beginning of the 20th century in order to improve the circulation of the upper limbs, observing an effect on certain functions such as sweating, and it was adopted as an elective procedure for hyperhidrosis problems in the 1920's. Later, its popularity fell significantly, as patients were subjected to a major surgical procedure to mitigate a minor problem.

Towards the end of the 1980's, with the development of minimally invasive surgery, its application was initiated once again. Its popularity has grown so much that the technique is now used around the world and there are currently groups, mainly Swedish and Japanese, with great experience.

Most of the current evidence concerning thoracic SNS surgery and, specifically, for the treatment of localized primary hyperhidrosis, comes from observational studies. In these studies, there is a lack of uniformity in the definitions as well as in the measures and methods of reporting the results. This makes it difficult to compare the different series and extract generalizable conclusions.

The absence of guidelines for thoracic SNS surgery for the treatment of localized primary hyperhidrosis and other clinical entities incites us to produce such guidelines with the aim of improving, facilitating and unifying the management of patients with these pathologies. The recommendations have been established according to the GRADE system ("The Grades of Recommendation, Assessment, Development and Evaluation")[1] (table 1). In those aspects in which the scientific evidence is insufficient, we have included the recommendations agreed upon by consensus of the authors.

## Anatomophysiological Basis

The sympathetic autonomic nervous system is composed of three neurons: the neuron body of the first, called preganglionic or connector, is situated in the intermediolateral horn of the thoracolumbar spinal cord. Its axon reaches the ganglion of the chain through the anterior cord root and white communicating branch. The neuron body of the second neuron, located in the sympathetic ganglion (fig. 1), presents an amyelinic axon that leaves the chain through the grey communicating branch to the corresponding radicular nerve. This second neuron is known as the postganglionic fiber. The postganglionic neuron accompanies the cerebrospinal fibers in their trajectory towards the skin.

In 1938, List and Peet,[2] after the studies carried out with patients who had been sympathectomized at different levels of the sympathetic chain, described the sympathetic dermatomes, relating the preganglionic fibers with certain body regions, similar to the sensory dermatomes. The neuronal amplification existing between a preganglionic fiber and several postganglionic fibers mean that these sympathetic dermatomes overlap and are difficult to systematize.

In the thoracic portion of the sympathetic system, the existence of a series of ganglia is well documented, and their number usually correlates approximately with that of the thoracic spinal nerves. The first thoracic ganglion is usually fused with the lower cervical ganglion, forming the stellate or cervicothoracic ganglion. Except for the last three thoracic ganglia, the remainder rest against the heads of the ribs and are covered by the parietal pleura.

However, regarding the anatomic position of the thoracic SNS ganglia, various studies describe their most frequent location for identification in surgery. In most cases, the T2-T3 thoracic ganglia are located at the level of the intercostal spaces and not over the costal arch.[3]

In an exhaustive anatomical study in 2001, Ramsaroop identified multiple connections between the sympathetic chain and the intercostal nerves. He suggested that the denomination "Kuntz nerve" be limited to the intrathoracic rami at the level of the first intercostal space, and the remaining connections be called "additional sympathetic connections" or "additional communicating branches".[4]

## Primary Focal Hyperhidrosis

### *Definition, Symptoms and Diagnosis*

Hyperhidrosis is defined as an excessive production of eccrine sweat at one or at various levels of the organism. It usually causes serious social and occupational disorders. It is accepted that normal sweating of the skin could oscillate between 8 and 15 mcg/cm$^2$/min, including the surface of both hands.[5] It is an affectation of unknown etiology that starts during childhood, becomes manifest in adolescence and, without specific treatment, lasts a lifetime.

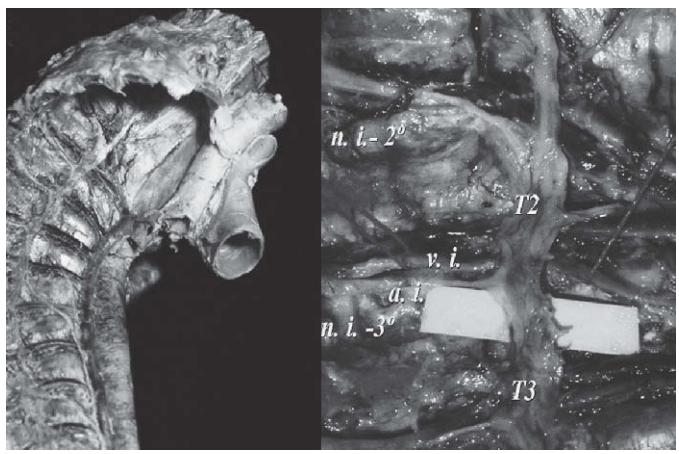


**Figure 1.** Thoracic sympathetic anatomy.
a. i.: intercostal artery; n. i.-2°: 2nd intercostal nerve; n. i.-3°: 3rd intercostal nerve; T2: 2nd thoracic sympathetic ganglion; T3: 3rd thoracic sympathetic ganglion; v. i.: intercostal vein.

**Table 1**
Classification of the recommendations and quality of scientific evidence according to the GRADE system

| Grade of recommendation | Quality of evidence | Implications |
|---|---|---|
| 1. Consistent recommendation;[a] high quality of evidence | Well-done RCT, or exceptionally well done OS | Apply in most patients under most circumstances |
| 2. Consistent recommendation;[a] moderate quality of evidence | RCT with limitations or well done OS with important effects | Apply in most patients under most circumstances |
| 3. Consistent recommendation[a] low quality of evidence | Evidence for at least one important result of an OS, or RCT with important major defects or very indirect evidence | May change when evidence becomes available |
| 4. Consistent recommendation;[a] very low quality of evidence | Evidence for at least one important result of non-systemic clinical observations or very indirect evidence | May change when greater evidence becomes available |
| 5. Weak recommendation;[b] high quality of evidence | Well-done RCT or exceptionally well-done OS | May differ depending on the circumstances or the patients |
| 6. Weak recommendation;[b] moderate quality of evidence | RCT con limitaciones o OS bien realizados con efectos importantes | Other alternatives may be better for some patients under certain circumstances |
| 7. Weak recommendation;[c] low quality of evidence | Evidence for at least one important result of OS or RCT with important major defects or indirect evidence | Other alternatives may be equally reasonable |
| 8. Weak recommendation;[d] very low quality of evidence | Evidence for at least one important result of non-systematic clinical observations or very direct evidence | Other alternatives may be equally reasonable |

OS: observational studies; RCT: randomized clinical trials.
[a]The benefits clearly outweigh the drawbacks, or vice-versa.
[b]The benefits are in balance with the drawbacks.
[c]Uncertainty in the estimation of the benefits or drawbacks; the benefits may be in balance with the drawbacks.
[d]Major uncertainty in the estimation of the benefits or drawbacks; the benefits may or may not be in balance with the drawbacks.

Somewhat more frequent in women, there is an evident family predisposition and its incidence is higher in certain populations (Asians and Sephardi Jews), representing 1% of the population.[6] The affection is bilateral, symmetrical and is sometimes related with or exacerbated by emotional or seasonal situations.

Although there are generalized forms, focal hyperhidrosis is the most frequent presentation. Palmar and axillary hyperhidrosis are the most common, followed by plantar hyperhidrosis. There is usually a combination of two or more affected foci, without being considered generalized hyperhidrosis. Despite its notable incidence, only a small percentage of these patients consult with their doctors as most know nothing of the possibilities for treatment.[7]

The diagnosis of primary focal hyperhidrosis is based on symptoms, supported by a proper clinical history. Data related with family history, distribution pattern, symptom frequency, etc. help distinguish focal from generalized hyperhidrosis. Along this line, the Multi-Specialty Working Group on Hyperhidrosis in the United States has proposed some criteria for the diagnosis of focal hyperhidrosis (table 2).[8]

Although anxiety has been reported to be a common component in the clinical history of these patients, it seems to be more of a reactive behavior to the disorder and not the hyperhidrosis itself that affects the daily activities of these patients.[9]

Different tests have been proposed to evaluate this affectation. Lab tests are not necessary in the diagnosis of primary hyperhidrosis, although they may be helpful in ruling out other diseases that produce secondary hyperhidrosis (infectious syndromes, hyperthyroidism, cardiopathy, pheochromocytoma, carcinoid tumor, etc). As for measuring hyperhidrosis, different methods have been proposed. Evaporimetry, which measures the quantity of sweat evaporated by these patients, has been proposed by Krogstad[10] as a method of quantifying skin sweat. Gravimetry calculates the rate of sweat production per minute. These and other tests (iodine-starch test, ninhydrin test) have been recommended in the diagnosis for hyperhidrosis in the specialty of Dermatology, especially in studying the effectiveness of the treatment with botulinum toxin.[11]

**Table 2**
Criteria for primary focal hyperhidrosis diagnosis

- Focal, visible excessive sweating for a period of at least six months with no known secondary cause
- At least one of the following characteristics:
  - Bilateral and symmetrical
  - Frequency of at least one episode per week
  - Interferes with daily activities
  - Presentation before the age of 25
  - Family history
  - Cessation of excessive sweating during sleep

*Classification and Differential Diagnosis*

Hyperhidrosis can be classified according to the area of the affectation into two types:

- Localized or focal: predominantly in specific areas; there are different forms:
  - Idiopathic/primary hyperhidrosis with affectation of the palms, soles of the feet, axilla, and the inguinal or craniofacial regions
  - Frey Syndrome or gustatory sweating
  - Neurological, as occurs in certain neuropathies and diseases that affect the spinal cord
- Systemic or generalized: a variation with all-over skin affectation. This is observed in a wide range of conditions and diseases: pregnancy, obesity, menopause, anxiety, hyperthyroidism, pheochromocytoma, carcinoid tumor; as well as in different dermatological disorders, such as vitiligo, pachydermoperiostosis, bullous epidermolysis, etc. A structural lesion of thoracic SNS can cause sweating anomalies. Tumors of the cerebral cortex, stroke, or infections can produce contralateral hyperhidrosis. Diseases of the spinal cord (syringomyelia, cord lesion, tabes dorsalis) can also cause diaphoresis.[12]

**Table 3**
Secondary hyperhidrosis

- Skin diseases: fungus, bacteria, contact dermatitis, etc.
- Fever
- Endocrinological: hyperthyroidism, pheochromocytoma, hyperpituitarism, carcinoid syndrome, acromegaly, obesity, diabetes, menopause, pregnancy
- Systemic infections: tuberculosis, endocarditis
- Cardiovascular: shock, cardiac insufficiency, respiratory insufficiency
- Drugs: fluoxetine, venlafaxine, alcohol, abstinence from opiates, anticholinesterases, pilocarpine, alprazolam, lorazepam, mercury, arsenic, acrylamide, proton pump inhibitors
- Neurological
  - Parkinson's disease
  - Spinal cord affectation:
    - Cord lesion, syringomyelia or tabes
  - Cerebrovascular accident
- Oncological
  - Myeloproliferative syndromes
  - Hodgkin disease
- Central nervous system disorders:
  - Cerebral tumors, vascular cerebral accidents
  - Familial primary hyperhidrosis: neurological disorder characterized by excessive sweating, usually focal, with associated family history
- Psychogenic
- Skin diseases: vitiligo, epidermolysis bullosa, pachydermoperiostosis, keratolysis punctata, exercise urticaria, Raynaud's syndrome, perniosis, panniculitis, acrocyanosis, lupus erythematosus (localized forms), erythema ab igne
- Chronic mercury intake

Depending on its origin, hyperhidrosis can be classified as[5-12]:
- Primary or essential hyperhidrosis: predominantly on palms, soles of feet, axilla, mammary fold and craniofacial region.
- Secondary hyperhidrosis (table 3).

*Medication*

There are many recent studies that have reviewed the non-surgical treatments of primary focal hyperhidrosis. Haider and Solish have analyzed the evidence of medical treatments for localized hyperhidrosis in nine studies using aluminum chloride, iontophoresis and botulinum toxin.[7]

*Topical Treatment*

Aluminum salts in the form of chloride or hydrochloride are the most commonly used. The "antiperspirants" that are found on the market contain small concentrations that range between 15 and 19%. The mechanism of action of these products is based on the mechanical occlusion of the eccrine sweat gland ducts during a period of time, causing atrophy of the secretory cells over the long term.[13]

In those patients in whom commercial antiperspirants are not effective, prescription preparations with higher concentrations of aluminum are recommended, such as 20% aluminum chloride in ethanol (Drysol©) or 6.25% aluminum tetrachloride (Xerac©). The evidence shows that high concentrations of aluminum salts are the first-choice topical treatment in the management of focal primary hyperhidrosis.[14]

*Iontophoresis*

Iontophoresis consists of the application of ionizing substances through the skin by means of alternating current. A continuous current of 20-50 V is used with a maximum amperage of 15-30 mA. Alternating current reaches the same results by applying lower currents of 8-12 mA and a set voltage of 16 V. For those individuals in whom iontophoresis is not effective, some authors recommend adding anticholinergics to the treatment.[15]

*Botulinum Toxin*

The use of botulinum toxin A (BTX-A) is an effective treatment for axillary hyperhidrosis, with an effectiveness of 90% 4 weeks after initiating the treatment.[8] The results are not as good in patients with palmar hyperhidrosis and it is hardly useful in plantar or craniofacial hyperhidrosis.

BTX-A is administered intradermally. In the axillary region, the recommended dosage is 50 U in each axilla, diluted in 0.9% saline solution. For the palmar region, the recommendation is 100 U in each hand. Several injections are given in a uniform distribution, separated 1-2 cm. The Minor test (starch-iodine) is necessary to identify the area to be treated. After the application of BTX-A the test is repeated to check the degree of response.[7]

Between the 2nd and 4th day after treatment, the patient begins to notice a reduction in sweating, which should become quite evident after the 2nd week. The administration of BTX-A should be repeated every 4-17 months.

*Systemic Treatment*

Oral treatments with anticholinergics have been used with debatable results in cases of severe hyperhidrosis. Results are better in patients with compensatory sweating (CS) after surgical treatment. Oxybutynin (Ditropan©) in dosages of 5-15 mg/day and tolterodine (Ditrusitol©) at 4 mg/day are the most often used.

The association of anticholinergic agents with sedatives or tranquilizers is used, although it is poorly tolerated by patients, as it can produce blurry vision, dry mouth, drowsiness and urinary retention. On many occasions, these symptoms lead to suspension of the treatment.[7]

*Surgical Treatment*

*Indications*

Thoracic sympathectomy is mainly indicated in cases of craniofacial, palmar and axillary hyperhidrosis with a poor response to medical treatment.[16,17] Other disorders in which it may be used are facial flushing, Raynaud's syndrome and disorders of mainly vascular origin in the upper extremities.[18] Splanchnicectomy is used, almost exclusively, in patients with abdominal pain that is resistant to medical treatment.[19,20]

Once the indication for surgery is established, the patient must be informed of the practically permanent character of the intervention and the possible adverse effects that may appear.

*Technique*

*Position.* The position of the patient depends on the type of interruption of the sympathetic chain and on whether the approach is unilateral or bilateral. When the technique used for sympatholysis is the resection of the chain or ganglion, the position in lateral decubitus is best for intervention as it allows for the use of different instruments and provides more comfortable exposure of the pleural cavity. The rest of the techniques for interrupting the chain can be done comfortably from the semi-Fowler position, described further on.

The approach is rarely unilateral; in these cases it is more advisable to use lateral decubitus position as it allows for better identification of the first two ribs. The position in prone decubitus, less often used, also allows for access to both hemithoraces without modifying the placement of the patient on the operating table.

There are no studies demonstrating the superiority of one position over another. Daily practice and most case series published maintain

**Table 4**
Levels of action used by different authors

| | Lin-Telaranta et al[23] (2001) | Yoon et al[28] (2003) | Loscertales et al[29] (2004) | Neumayer et al[25] (2004) | Moya et al[16] (2006) | Chou et al[24] (2006) | Weksler et al[30] (2008) | BTSS[26] (2008) | Liu et al[31] (2009) | Fibla et al[27] |
|---|---|---|---|---|---|---|---|---|---|---|
| Flushing | T2 | - | - | - | - | T2 | T2 | T2 | - | T2 high |
| Cranio-facial | T3 | - | - | - | - | T3 | T2 | T2/T3 | - | T2 low |
| Palmar | T4 | T3 | T2 + T3 | T4 | T2 + T3 | T4 | T3 | T3/T4 | T4 | T3-T4 |
| Axillary | T4 | T3 + T4 | T2 + T3 | T4 | T2 + T3 + T4 | T5 | T3 + T4 | T4/T5 | - | T4-T5 |

that the most common position is the semi-Fowler, which helps separate the lung from the vertex of the rib cage. The patient is positioned semi-sitting, with his/her arms separated at a 90° angle and with a slight rotation towards the opposite side of the intervention. This position allows for access to both hemithorax without modifying the situation of the patient on the surgical table.[21]

*Anesthesia.* Different techniques are used for the intraoperative ventilation of these patients. Orotracheal intubation with a double-lumen tube is most commonly used, but there are reports of the use of ventilation with laryngeal mask as well as surgery under sedation with spontaneous ventilation, with satisfactory results.[22] If bipulmonary ventilation with an orotracheal tube is chosen, the pneumothorax chamber can be prepared with short pauses of apnea that allow for access to the chain. $CO_2$ can be used with a pressure of up to 10 cm of $H_2O$ with a flow of 0.5-2 L/min, enough to collapse the lung vertex and separate it from the superior sulcus.[21]

*Ports of Entry.* Usually, two ports of entry are made. One is for the optical and illuminating system, and the other for introducing the instruments for performing the surgical technique. If a thoracoscope with a work canal is to be used, only one entry port is necessary.[21]

*Types of Interruption.* There are different options for interrupting the chain, and none has been shown to be better than the others. Chain cutting, which is done over the rib, ganglia resection, ramicotomy and thermocoagulation ablation, are permanent techniques. The interruption of the thoracic SNS chain by "clipping", either above the rib or above and below the ganglion, is a potentially reversible technique.
Permanent techniques are most often used for patients with palmar-plantar hyperhidrosis, where the probability for requiring reversibility is low. Candidates for the reversible technique are those patients in whom the therapeutic benefit is more doubtful and there is greater risk for CS. Included in this group are those patients with craniofacial or axillary hyperhidrosis, or facial flushing.[21]

*Cut level.* One of the most delicate points when carrying out a sympatholysis is choosing the most adequate level on the sympathetic chain where to act. A recommendation of T3, for example, means cutting over the 3rd rib.

The difficulty for determining the ideal level where to act is basically conditioned by two factors:

1. Regarding effectiveness and side effects, the results reported by different authors who have tried to find the ideal level for the procedure do not coincide, which until now has made it impossible to specify guidelines accepted by all as being ideal.
2. Neuroanatomical studies have given us a better understanding of the typical distribution of the sympathetic system, but they also reveal the frequent existence of anatomical variations.

In this regard, it is therefore necessary to use a clinical classification that serves to later be able to recommend plans of action. It is practical to follow the one published by Lin-Telaranta,[23] used by different authors,[24,25] that classifies sympathetic dysfunction into three categories. The first category is patients diagnosed with facial flushing, the second is patients that suffer cranio -facial hyperhidrosis with or without facial blushing, and the third is for cases of palmar and axillary hyperhidrosis. A more detailed classification is used by the Brazilian Society of Thoracic Surgery[26] in which the former categories are subdivided depending on the intensity of the symptoms.

Using the Lin-Teleranta classification as a basis, the results of various authors can be analyzed (table 4)[16,23-31] finding enough differences between them to not be able to categorically indicate the precise levels for action, but at the same time finding enough evidence to recommend specific cut levels:

– Patients with facial flushing and/or sweating: cut level T2 and/or T3.
– Patients with palmar hyperhidrosis: cut level T3 and/or T4.
– Patients with axillary hyperhidrosis: cut level T4 or T4-T5

The existence of accessory pathways in the thoracic SNS was documented in 1927 by Kuntz[32] after discovering the existence of a nervous connection that from the 2nd intercostal nerve reached the brachial plexus without passing through the 2nd sympathetic ganglion. The eponym "Kuntz nerve" has been generally used to refer to the group of alternative sympathetic fibers of the thoracic SNS, although according to Ramsaroop[4] it should be used exclusively for the rami located in the first intercostal space. Its prevalence has been estimated to be at around 10% of surgical explorations.

In the same manner, Kim[33] has found accessory pathways lateral and medial to the sympathetic chain at the height of the 3rd rib head in 12.5 and 9%, respectively.

The existence of the Kuntz nerve and accessory pathways has been classically reported as a cause of therapeutic failure in palmar hyperhidrosis.[34] There is, however, evidence that recommends trying to identify and interrupt the Kuntz nerve as well as laterally extending the coagulation along the upper and lower costal edges.

*Instruments.* Although the first video-assisted thoracic sympathicotomies were systematically performed with diathermia, since 1996, when the clinical application of the harmonic or ultrasound scalpel was initiated, its application has been contemplated in the area of thoracic SNS surgery. Its advantage over cauterization is that it does not generate heat in the area of its application, which reduces the probability of injury to the stellate ganglion and other neighboring structures. However, currently there is no scientific evidence that the harmonic scalpel should be the instrument of choice.[35]

*Drains and Postoperative Care.* After completion of the procedure, it is recommended to insert a fine drain in the 5-mm port connected to a

**Table 5**
Results in the literature on clip removal

| Authors | N | Removal of the "clip" (%) | Improvement (%) | Comments |
|---|---|---|---|---|
| Lin et al.[45] | 326 | 5 (1.5) | 4/5 (80) | Improvement one year after removal |
| Reisfeld et al.[51] | 326 | 5 (1.4) | 3/5 (60) | – |
| Lin and Chou et al.[47] | 102 | 2 (2) | 2/2 (100) | – |
| Chou et al.[24] | 56 | 13 (23) | 10/13 (77) | – |
| Reisfeld et al.[48] | 1,274 | 31 (2.4) | 25/31 (81) | Removal within the first 6 months |
| Jo et al.[49] | 87 | 9 (10.3) | 8/9 (90) | Short-term results |
| Kang et al.[50] | 116 | 15 (12.9) | 9/14 (64) | Short and mid-term results |
| Reisfeld et al.[46] | 2,250 | 36 (1.6) | 13/25 (52) | Long-term results |

water seal system in order to evacuate the pneumothorax generated by the intervention. Proper treatment of nausea, vomiting, and postoperative pain has made this procedure become part of surgical outpatient programs.[36,37]

*Results.* Intraoperative efficacy and results of the technique are usually observed by evaluating the increase of the pulse wave with a pulse-oxymeter and by observing the increase in temperature thanks to a temperature sensor placed in the thenar eminence, both in the upper limb on the side of surgery. Blood flow can also be measured with Doppler laser.[38]

Recurrence of hyperhidrosis appears in 1-27% of cases in the three years following surgery. 76% of the recurrences occur within the first 6 months and are usually moderate. They have been related with surgeon experience, anatomical variations, incomplete interruption of the sympathetic chain or possible nerve regeneration.[39] Transitory periods of palmar hyperhidrosis may appear between the 1st and 7th day after the operation, but these should not be considered an error in technique as they later disappear definitively.

Improvement in symptoms is always more than 90%, but the degree of satisfaction depends on the intensity of CS, which is serious in 1-30% of patients, depending on the series.[40,41] The improvement and degree of satisfaction are greater in palmar than in axillary hyperhidrosis.

*Complications.* A distinction should be made between complications, at around 10%, and undesired or side effects.

*Intraoperative Complications.* The anatomical variability of the thoracic SNS chain, the presence of abundant adipose tissue or the existence of multiple adherences can, on occasion, complicate or even impede the surgical procedure. The production of arterial or venous lesions and the appearance of alterations in rhythm, like bradycardia, are almost anecdotal.

*Postoperative Complications.* The most frequent postoperative complication is the appearance of pneumothorax, which is usually small and requires pleural drainage in 30% of cases. In a few patients, pleural effusion, hemothorax or chylothorax can occur.[39] In general, pain is moderate and is resolved with conventional analgesics over a maximum period of 2 to 4 weeks. Horner syndrome appears permanently in less than 0.5% of cases. Other less frequent complications are subcutaneous emphysema, infection of the surgical wound, the presence of segmental atelectasis and transitory lesion of the brachial plexus.[41]

*Undesired or Side Effects.* Compensatory sweating (CS) is defined as intense sweating in other anatomical areas after sympathectomy: the dorsal region, abdomen, inguinal region and thighs. This situation can change over time and is usually difficult to evaluate. According to the series reviewed by Dumont, the mild form oscillates between 15 and 90% and the severe form between 1 and 30%.[41] According to some authors, the higher up the sympathectomy is done (T2) and the more extensive the resection (T2–T5), the greater the probabilities of there being serious CS.[39,41]

Other undesired effects occur less frequently. Among these are gustatory sweating (1-32%) and dry hands (42%), which are usually well accepted by the patients, as is the rebound effect, which is during a limited time. The changes produced by thoracic sympathectomy on the small airway and cardiac frequency are not very significant from a clinical viewpoint.[39,42]

*Reversibility.* From the extensive literature published on this topic, what we have gathered is that the results and the side effects, including CS, are similar whatever the surgical technique used (sympathectomy, sympathicotomy, ramicotomy or clipping). Nevertheless, the procedures that cut the nerve all have in common the fact that they are irreversible.[41]

The options for CS treatment in these cases are very limited. Several authors have tried to reconstruct the sympathetic chain by inserting grafts from different nerves, with very different results.[43,44]

Clipping of the sympathetic chain was developed as the only procedure that, until the moment, would be able to revert the effects of the thoracic SNS blockage. The experience published concerning the removal of the "clip" is quite varied. Table 5[24,45-51] details the main series found in the literature. The authors have reported different results, with an improvement ranging from 52 to 100%.

The long-term results are promising although the evidence shows that the effect of clip removal requires more studies to be fully understood. Nevertheless, the mere fact that reversibility is a real option, with acceptable long-term results, makes clipping more attractive than the other types of techniques.[27]

## Other Indications for Thoracic Sympathetic Nervous System Surgery

*Vasomotor Disorders*

Vascular alterations that are susceptible to improvement with thoracic SNS intervention are described below:

*Facial Flushing*

Facial flushing or blushing is defined as the sensation of heat and redness on the face, ears, neck and occasionally the upper part of the thorax due to a transitory increase in the blood flow in these locations. Its incidence is not clear, but its geographical variations are known, being frequent in Scandinavian countries and rare in Asia.[52]

Given a person affected by facial flushing, the first step is to exclude a subjacent cause, such as carcinoid syndrome. The first therapeutic option is medical treatment with beta-blockers, anxiolytics, serotonin recapture inhibitors and other antidepressants.

Although the results with this type of treatment are not very hopeful, they should be tried before surgery.

In this pathology, the intradermal use of botulinum toxin type A is not indicated until well-designed studies are shown to be effective. Once medical treatment has been tried and has not been effective, video-assisted thoracic sympathectomy can be performed with the interruption of T2.[53]

*Raynaud's Syndrome*

Surgical indication is fundamentally in the primary form and when there are serious long-term symptoms that are refractory to pharmacological treatment. The current use of some drugs (prostaglandins, vasodilators, anticoagulants) and general measures against the cold (gloves) should be considered first before contemplating the indication for surgery. The presence of ulcerations on the fingers, associated with painful symptoms that limit and impede daily activities, reinforce the indication for surgery. The results, with the interruption of the sympathetic chain at the same level as for palmar sweating, are acceptable but not as satisfactory as those of primary hyperhidrosis.[18]

*Peripheral Obstructive Arteriopathy and Buerger's Disease.* Sympathectomy at the T2-T3 level is indicated in the case of advanced-stage disease that does not respond to treatment with medication, or when this is contraindicated, or if direct surgical revascularization is not possible.[54] The presence of ulcers or gangrene represents the ideal, universally-accepted indication, although intervention can be proposed in earlier stages if there are intense, painful symptoms even at rest. Quite variable therapeutic success percentages have been published.[55]

*Coronary Syndromes.* Before the use of modern drugs, the only way to block the sympathetic nervous system of the heart was ablation of the sympathetic chain at a certain height. Although there is no consensus about the level of the cut, T3-T4 or T4-T5, it seems to be accepted that it should always include the 4th dorsal sympathetic ganglion. From the 1930's to the 1950's, open thoracic sympathectomy was used for the treatment of angina pectoris and tachyarrhythmia. With the development of new, more specific drugs, this indication almost disappeared and is reserved only for cases of refractory arrhythmias or angina patients who do not respond to conventional therapy and cannot undergo revascularization therapy.[56]

*Reflex Sympathetic Dystrophy*

Reflex sympathetic dystrophy, also called complex regional pain syndrome, is an affectation that presents a wide range of symptoms. It is a multisystem affectation and usually involves one or more limbs, although it can affect any part of the body.

In these patients, the application of different sympathetic block techniques should always be tried as, if a remission in the symptoms is produced, in addition to confirming this syndrome, it helps identify those patients who could benefit from permanent sympathectomy.[57] The level and length of the extirpation of the sympathetic chain varies depending on the area affected. In general, for lesions of the upper limbs, from T2 to T4 or T5 is recommended. There are, however, no consensus or randomized studies demonstrating this, therefore the degree of scientific evidence is very low.

*Treatment of Abdominal Pain: Splanchnicectomy*

The treatment of abdominal pain in patients with pancreatic carcinoma or chronic pancreatitis is another indication for the exeresis of a segment of the sympathetic chain, in this case of the splanchnic nerve. In 1943, Mallet-Guy[58] showed that the sympathetic denervation of the pancreas produces an interruption in the pain stimulus in this type of patients. The indication for splanchnicectomy is proposed when treatment with medication fails and if the pancreatic duct is not dilated or is small.

It is recommended to access the sympathetic chain by sequential bilateral video-assisted thoracoscopy with the patient lying in lateral decubitus position, on one side first, then on the other. The semi-Fowler position is not apt for accessing this caudal segment of the thoracic SNS. Through three ports of entry, one 10 mm for the camera and two 5 mm for the surgical instruments, the dorsal sympathetic chain is located and is followed in the caudal direction in order to identify the major and minor splanchnic nerves. To date, the technique indicated is extirpation.

Regarding the percentage for success, quite disparate data have been published that oscillate between 94% by Moodley[19] (with a follow-up of only 12 months) and 31% by Howard.[20]

## Appendix A. Specific Recommendations[1]

**Note:** No mention is made for the degree of recommendation in circumstances that imply common or recommended practice, as other alternatives are not evaluable from an ethical standpoint.

*A.1. Primary Focal Hyperhidrosis*

*A.1.1. Definition, Symptoms and Diagnosis*

– Lab work is not necessary to diagnose primary hyperhidrosis, although it is recommended to rule out other diseases that produce secondary hyperhidrosis. R4 (Consistent recommendation; very low quality of evidence).

*A.1.2. Medication*

– High concentration aluminum salts are the topical treatment of choice recommended in the treatment of primary focal hyperhidrosis. R2 (consistent recommendation; moderate quality of evidence).
– The use of botulinum toxin A is very effective in the control of axillary hyperhidrosis (90%). The results are not as good in patients with palmar hyperhidrosis and of little use in plantar and craniofacial hyperhidrosis. R2 (consistent recommendation; moderate quality of evidence).

*A.1.3. Surgical Treatment*

*A.1.3.1. Indications*

– When treatment with medication fails, the treatment of palmar hyperhidrosis should be the interruption of the sympathetic chain via thoracoscopy, a technique with safe and effective results. R1 (consistent recommendation; high quality of evidence).
– In the treatment of axillary and/or craniofacial hyperhidrosis, thoracoscopic sympatholysis should be considered as a therapeutic option. R3 (consistent recommendation; low quality of evidence).
– The specialist must inform the patient in detail of all the results and possible side effects of sympatholysis as this may influence the decision of the patient. R2 (consistent recommendation; moderate quality of evidence).

Surgical technique

– Recommendations for specific cut levels. R2 (consistent recommendation; moderate quality of evidence):
  • Patients with facial flushing and/or sweating: cut at level T2 and/or T3.

- Patients with palmar hyperhidrosis: cut at level T3 and/or T4.
- Patients with axillary hyperhidrosis: cut at level T4 or T4-T5.

– It is recommended to identify and interrupt the Kuntz nerve, as well as to extend the coagulation laterally along the corresponding rib segment. R2 (consistent recommendation; moderate quality of evidence).
– In primary essential hyperhidrosis, the access must be bilateral, in the semi-Fowler position, and with one or two points of entry. R2 (consistent recommendation; moderate quality of evidence).
– The procedure can be done without pleural drain or with early retirement of the drain. R2 (consistent recommendation; moderate quality of evidence).
– Thoracic sympatholysis can be included in outpatient surgery programs, given the small rate of associated morbidity. R2 (consistent recommendation; moderate quality of evidence).

*A.2. Other Indications for Thoracic Sympathetic Nervous System Surgery*

*A.2.1. Facial Flushing/Blushing*

– The surgical treatment for facial flushing by the interruption of the dorsal sympathetic chain at the T2 level by video-assisted thoracoscopy should be considered when treatment with medication has failed. R2 (consistent recommendation; moderate quality of evidence).

*A.2.2. Other Indications for Sympathectomy*

– The decision to perform a sympathectomy in situations such as Raynaud's syndrome, Buerger's disease, coronary syndrome and untreatable abdominal pain should be based on an individualized patient study and the joint evaluation with other medical specialists involved in their treatment. R4 (consistent recommendation; very low quality of evidence).

## References


1. Schunemann HJ, Jaeschke R, Cook DJ, Bria WF, El-Solh AA, Ernst A, et al. An official ATS statement: grading the quality of evidence and strength of recommendations in ATS guidelines and recommendations. Am J Respir Crit Care Med. 2006;174:605-14.
2. List CF, Peet MM. Sweat secretion in man. II Anatomic distribution of disturbances in sweating associated with lesions of the sympathetic nervous system. Arch Neurol Psychiatry. 1938;40:27-43.
3. Chung IH,OhCS, Koh KS. Anatomic variations of the T2 nerve root (including the nerve of Kuntz) and their implications for sympathectomy. J Thorac Cardiovasc Surg. 2002;123:498-501.
4. Ramsaroop L, Singh B, Moodley J. Anatomical basis for a successful upper limb sympathectomy in the thoracoscopic era. Cin Anat. 2004;17:294-9.
5. Moreno Balsalobre R, Pun Tam YW, Prieto Vicente V, Fernández Fau L. Nuevas perspectivas para la hiperhidrosis palmar y axilar: simpatectomía torácica por videotoracoscopía. Rev Patol Respir. 2000;3:71-4.
6. Ro KM, Cantor RM, Lange KL, Ahn SS. Palmar hyperhidrosis: evidence of genetic transmission. J Vasc Surg. 2002;35:382-6.
7. Haider A, Solish N. Focal hyperhidrosis: diagnosis and management. CMAJ. 2005;172:69-75.
8. Hornberger J, Grimes K, Naumann M, Glaser DA, Lowe NJ, Naver H, et al., Multi-Specialty Working Group on the Recognition. Diagnosis and Treatment of primary focal hyperhidrosis. J Am Acad Dermatol. 2004;51:274-86.
9. Ramos R, Moya J, Turón V, Pérez J, Villalonga R, Morera R, et al. Hiperhidrosis primaria y ansiedad: estudio prospectivo preoperatorio de 158 pacientes. Ach Bronconeumol. 2005;41:88-92.
10. Krogstad AL, Skymne A, Pegenius G, Elam M, Wallin G. Evaluation of objective methods to diagnose palmar hyperhidrosis and monitor effects of botulinum toxin treatment. Clin Neurophysiol. 2004;115:1909-16.
11. Swinehart JM. Treatment of axillary hyperhidrosis: combination of the starch-iodine test with the tumescent liposuction technique. Dermatol Surg. 2000;26:392-6.
12. Edmonson RA, Banerjee AK, Rennie JA. Endoscopic transthoracic sympathectomy in the treatment of hyperhidrosis. Ann Surg. 1992;215:289-93.
13. Holzle E, Braun-Falco O. Structural changes in axillary eccrine glands following long-term treatment with aluminium chloride hexahydrate solution. Br J Dermatol. 1984;110:399-403.
14. Grimalt R, Calleja M, editors. Hiperhidrosis: Diagnóstico y tratamientos actuales. Madrid: Editorial Médica Panamericana; 2004.
15. Dahl JC, Glent-Madsen L. Treatment of hyperhidrosis manuum by tap water iontophoresis. Acta Derm Venereol. 1989;69:346-8.
16. Moya J, Ramos R, Morera R, Villalonga R, Perna V, Macia I, et al. Resultados de la simpaticólisis y la simpatectomía torácica superiorbilateral endoscópica en el tratamiento de la hiperhidrosis primaria. Estudio de 1.016 procedimientos. Arch Bronconeumol. 2006;42:230-4.
17. Doolabh N, Horswell S, Williams M, Huber L, Prince S,MeyerDM,et al. Thoracoscopic sympathectomy for hyperhidrosis: indications and results. Ann Thorac Surg. 2004;77:410-4.
18. Matsumoto Y, Ueyama T, Endo M, Sasaki H, Kasashima F, Abe Y, et al. Endoscopic thoracic sympathicotomy for Raynaud's phenomenon. J Vasc Surg. 2002;36:57-61.
19. Moodley J, Singh B, Snaik A, Haffejee A, Rubin J. Thoracoscopic splanchnicectomy: pilot evaluation of a simple alternative for chronic pancreatic pain control. World J Surg. 1999;23:688-892.
20. Howard T, Swofford J, Wagner D, Sherman S, Lehman G. Quality of life alter bilateral thoracoscopic splanchnicectomy: long-term evaluation in patients with chronic pancreatitis. J Gastrointest Surgery. 2002;6:845-54.
21. Baumgartner FJ. Surgical approaches and techniques in the management of severe hyperhidrosis. Thorac Surg Clin. 2008;18:167-81.
22. Hsieh YJ, Chen CM, Lin HY, Young TF. Experience of anesthesia during transthoracic endoscopic sympathectomy for palmar hyperhidrosis: comparison between double-lumen endobronchial tube ventilation and laryngeal mask ventilation. Acta Anaesthesiol Sin. 1994;32:13-20.
23. Lin CC, Telaranta T. Lin-Telaranta classification: the importance of different procedures for different indications in sympathetic surgery. Ann Chir Gynaecol. 2001;90:161-6.
24. Chou SH, Kao EL, Lin CC, Chang YT, Huang MF. The importance of classification in sympathetic surgery and a proposed mechanism for compensatory hyperhidrosis: experience with 464 cases. Surg Endosc. 2006;20:1749-53.
25. Neumayer C, Zacherl J, Holak G, Fugger R, Jakesz R, Herbst F, et al. Limited endoscopic thoracic sympathetic block for hyperhidrosis of the upper limb: reduction of compensatory sweating by clipping T4. Surg Endosc. 2004;18:152-6.
26. Menezes R, Ribas J, Wen D, Paiula M, Bessa M, Gesteira M, et al. Guidelines for the prevention, diagnosis and treatment of compensatory hyperhidrosis. J Bras Pneumol. 2008;24:967-77.
27. Fibla J, Molins L, Mier J, Vidal G. Effectiveness of sympathetic block by clipping in the treatment of hyperhidrosis and uncontrollable facial blushing. Interac Cardiovasc Thorac Surg. Doi: 10.1510/icvts. 2009. p. 212-365.
28. Yoon DH, Ha Y, Park YG, Chang JW. Thoracoscopic limited T-3 sympathicotomy for primary hyperhidrosis: prevention for compensatory hyperhidrosis. J Neurosurg. 2003;99:39-43.
29. Loscertales J, Arroyo Tristán A, Congregado Loscertantes M, Jiménez Merchan R, Girón Arjona J, Arenas Linares C. Tratamiento de la hiperhidrosis palmar por simpatectomía torácica. Resultados inmediatos y calidad de vida postoperatoria. Arch Bronconeumol. 2004;40:67-71.
30. Weksler B, Luketich JD, Shende MR. Endoscopic thoracic sympathectomy: at what level should you perform surgery? Thorac Surg Clin. 2008;18:183-91.
31. Liu Y, Yang J, Liu J, Yang F, Jiang G, Li J, et al. Surgical treatment of primary palmar hyperhidrosis: a prospective randomized study comparing T3 and T4 sympathicotomy. Eur J Cardiothorac Surg. 2009;35:398-402.
32. Kunt A. Distribution of the sympathetic rami to the brachial plexus. Its relation to sympathectomy affecting the upper extremity. Arch Surg. 1927;15:871-7.
33. Kim do H, Hong YJ, Hwang JJ, Kim KD, Lee DY. Topographical considerations under video-scope guidance in the T3,4 levels sympathetic surgery. Eur J Cardiothorac Surg. 2008;33:786-9.
34. Singh B, Moodley J, Ramdial PK, Ramsaroop L, Satyapal KS. Pitfalls in thoracoscopic sympathectomy: mechanisms for failure. Surg Laparosc Endosc Percutan Tech. 2001;11:364-7.
35. Callejas MA, Rubio M, Iglesias M, Belda J, Canalis E, Catalán M, et al. Simpatectomía torácica por videotoracoscopia para el tratamiento del ruborfacial: bisturí ultrasónico frente a diatermia. Arch Bronconeumol. 2004;40:17-9.
36. Molins L, Fibla JJ, Mier JM, Sierra A. Outpatient thoracic surgery. Thorac Surg Clin. 2008;18:321-7.
37. Moreno Balsalobre R, Pun Tam YW, García Fernández JL, Risco Rojas R, Amor Alonso S, Roses Roses R, et al. Simpatectomía Torácica por Cirugía Mayor Ambulatoria (CMA). ¿Se pierde calidad asistencial? Arch Bronconeumol. 2008;44:104S.
38. Li X, Tu YR, Lin M LF, Chen JF, HWM. Minimizing endoscopic thoracic sympathectomy for primary palmar hyperhidrosis: guided by palmar skin temperature and laser doppler blood flow. Ann Thorac Surg. 2009;87:427-31.
39. Rodríguez PM, Freixinet JL, Hussein M, Valencia JM, Gil RM, Herrero J, et al. Side effects, complications and outcome of thoracoscopic sympathectomy for palmar and axillary hyperhidrosis in 406 patients. Eur J Cardiothorac Surg. 2008;34:514-9.
40. Molins L, Simon C, Buitrago J, Vidal G. Tratamiento quirúrgico de la hiperhidrosis palmar y axilar. Arch Bronconeumol. 2003;39 Suppl 6:S50-6.
41. Dumont P. Side effects and complications of surgery for hyperhidrosis. Thoracic Surg. 2008;18:193-207.
42. Congregado M. Impacto de la simpatectomía dorsal videotoracoscópica en la cirugía torácica. Implicaciones futuras. Arch Bronconeumol. 2009;46:1-2.
43. Teleranta T. Secondary sympathetic chain reconstruction after endoscopic thoracic sympathicotomy. Eur J Surg. 1998;164 Suppl 580:S17-8.

44. Latif MJ, Afthinos JN, Connery CP, Perin N, Bhora FY, Chwajol M, et al. Robotic intercostal nerve graft for reversal of thoracic sympathectomy: a large animal feasibility model. Int J Med Robot. 2008;4:258-62.
45. Lin CC, Mo LR, Lee LS, Ng SM, Hwang MH. Thoracoscopic T2-sympathetic block by clipping-a better and reversible operation for treatment of hyperhidrosis palmaris: experience with 326 cases. Eur J Surg Suppl. 1998:13-6.
46. Reisfeld R. Sympathectomy reversal. Clamping vs Nerve graft. Eighth International Symposium on Sympathetic Surgery (ISSS).NewYork, USA: March 25-27, 2009.
47. Lin TS, Chou MC. Treatment of palmar hyperhidrosis using needlescopic T2 sympathetic block by clipping: analysis of 102 cases. Int Surg. 2004;89:198-201.
48. Reisfeld R. Sympathectomy for hyperhidrosis: should we place the clamps at T2-T3 or T3-T4? Clin Auton Res. 2006;16:384-9.
49. Jo KH, Moon SW, Kim YD, Sim SB, Cho DG, Jin U, et al. New protocol for a reversal operation in endoscopic thoracic sympathetic clamping: pulling back the suture sling linked to the clip under local anesthesia. Surg Laparosc Endosc Percutan Tech. 2007;17:29-32.
50. Kang CW, Choi SY, Moon SW, Cho DG, Kwon JB, Sim SB, et al. Short-term and intermediate-term results after unclipping: what happened to primary hyperhidrosis and truncal reflex sweating after unclipping in patients who underwent endoscopic thoracic sympathetic clamping? Surg Laparosc Endosc Percutan Tech. 2008;18:469-73.
51. Reisfeld R, Nguyen R, Pnini A. Endoscopic thoracic sympathectomy for hyperhidrosis: experience with both cauterization and clamping methods. Surg Laparosc Endosc Percutan Tech. 2002;12:255-67.
52. Licht PB, Pilegaard HK. Management of facial blushing. Thorac Surg Clin. 2008;18:223-8.
53. Malmimaara A, Kuukasjarvi P, Autti-Ramo I. Effectiveness and safety of endoscopic thoracic sympathectomy for excessive sweating and facial blushing: a systematic review. Int J Technol Assess Health Care. 2007;23:54-62.
54. Komori K, Kawasaki K, Okazaki J, Eguchi D, Mawatari K, OkadomeK, et al. Thoracoscopic sympathectomy for Buerger's disease of the upper extremities. J Vasc Surg. 1995;22:344-6.
55. DeGiacomo T, Rendina E, Venuta F, Lauri D, Mercadante E, Anile M. Thoracoscopic sympathectomy for symptomatic arterial obstruction of the upper extremities. Ann Thorac Surg. 2002;74:885-8.
56. Kumar P, Moussa F, Nesher N, Goldman B. History of surgical treatment of ischemic heart disease -pre'coronary by-pass grafting'- era. J Card Surg. 2007;22:242-6.
57. Fechir M, Geber C, Birklein F. Evolving understanding about Complex Regional Pain Syndrome and its treatment. Curr Pain Headache Rep. 2006;12:186-91.
58. Mallet-Guy P. La splanchnicectomie gauche dans le traitement des pancreatitis chroniques. Presse Med. 1943;51:145-6.