Thoracoscopic Sympathectomy and Compensatory Hyperhidrosis

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Abstract

Endoscopic Thoracic Sympathectomy (ETS) is a surgical procedure where certain portions of the sympathetic nerve trunk are destroyed. ETS is used to treat hyperhidrosis, facial blushing, Raynaud's disease and reflex sympathetic dystrophy. By far the most common complaint treated with ETS is palmar hyperhidrosis, or "sweaty palms". In this disorder, the palms may constantly shed so much sweat that the affected person is unable to handle paper, sign documents, keep clothes dry, or shake hands. The result is often social phobia so severe as to be disabling. Sympathectomy physically destroys some tissue anywhere in either of the two sympathetic trunks. The most common area targeted in sympathectomy is the upper thoracic region, that part of the sympathetic chain lying between the first and fifth thoracic vertebrae. In addition to the normal risks of surgery, such as bleeding and infection, sympathectomy has several specific risks, such as adverse changes in how nerves function. With ETS the results are very rewarding in relation to palmar hyperhidrosis, with the disappearance of the symptoms in all cases. Compensatory sweating, the most common side effect usually well tolerated, and the satisfaction index is quite high, so ETS is popular among patients and physicians. Immediate and short-term results of Endoscopic Thoracic Sympathectomy (ETS) for primary hyperhidrosis are excellent. Adverse effects have been identified clearly and are supposed to decrease with time. Compensatory Hyperhidrosis (CH) is the most common and distressing complication for sympathectomy, and it is the "quality marker" of ETS. It is characterized by the postoperative appearance of excessive perspiration in regions of the body where it had not been previously observed.

Keywords: Thoracoscopic Sympathectomy, Compensatory Hyperhidrosis

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Endoscopic Thoracic Sympathectomy (ETS) is a surgical procedure where certain portions of the sympathetic nerve trunk are destroyed. ETS is used to treat hyperhidrosis, facial blushing, Raynaud's disease and reflex sympathetic dystrophy. By far the most common complaint treated with ETS is palmar hyperhidrosis, or "sweaty palms". In this disorder, the palms may constantly shed so much sweat that the affected person is unable to handle paper, sign documents, keep clothes dry, or shake hands. The result is often social phobia so severe as to be disabling. Sympathectomy physically destroys some tissue anywhere in either of the two sympathetic trunks. The most common area targeted in sympathectomy is the upper thoracic region, that part of the sympathetic chain lying between the first and fifth thoracic vertebrae. In addition to the normal risks of surgery, such as bleeding and infection, sympathectomy has several specific risks, such as adverse changes in how nerves function **(1).**

Endoscopic Anatomy of the Upper Thorax for Sympathectomy

Right Upper Thorax: During thoracoscopic sympathectomy, the right upper thorax reveals crucial anatomical landmarks. The right superior intercostal vein is visible, draining into the azygos arch. This arch, formed at the T4 vertebra, contributes to the superior vena cava. The sympathetic chain lies beneath the parietal pleura, overlying the heads of the ribs and segmental blood vessels. Key nerves such as the vagus nerve, recurrent laryngeal nerve, and phrenic nerve are observable. Of particular importance is the stellate ganglion, situated adjacent to the first rib, a vital reference point for sympathectomy **(2).**

Figure (1): Thoracoscopic view of upper thoracic sympathetic chain.

Left Upper Thorax: Distinct anatomical structures on the left side include the aorta, arch vessels, recurrent laryngeal nerve, and venous structures. Noteworthy features are the left superior intercostal vein, left vagus nerve, and left phrenic nerve. It's essential to recognize anatomical differences between the right and left sides, accounting for the presence of the azygos vein and thoracic duct on the right side and the aorta and aortic arch on the left side. *Superior Intercostal Veins (SIVs):* The arrangement of Superior Intercostal Veins (SIVs) becomes significant during sympathectomy due to potential bleeding issues. The right SIV's position in relation to the sympathetic chain can be unpredictable, requiring careful attention. In contrast, the left SIV, located lateral to the second thoracic ganglion, is less susceptible to iatrogenic injury **(3).**

Prevertebral Fascia and Anatomical Differences: Close attention should be given to the prevertebral fascia covering the longus colli muscle, and surgeons must be mindful of anatomical disparities between the right and left sides. Factors such as the presence of the azygos vein and thoracic duct on the right side, as well as the aorta and aortic arch on the left side, demand careful consideration. *Azygos Lobe:* The azygos lobe, a normal variant of pulmonary anatomy, may pose challenges during sympathectomy by obstructing the view of the sympathetic chain. Surgeons must exercise caution to identify ganglia through a window cut in the mesentery without causing injury to the azygos vein. Comprehensive knowledge of these nuanced endoscopic anatomical details is imperative for ensuring a successful, precise, and safe thoracoscopic sympathectomy procedure **(4).**

Figure (2) (a) The azygos vein suspended on the mesoazygos. The azygos lobe has been dislocated from beneath the arch of the vein and a window cut in the mesentery. **(b)** Closer view showing the sites of ablation of the 2nd and 3rd sympathetic ganglia.

Patient selection

Surgical interruption of intrathoracic autonomic neural pathways has several useful clinical applications, particularly thoracic sympathectomy for upper limb hyperhidrosis and splanchnicectomy for relief of pancreatic pain. The advent of video-thoracoscopy has led to an explosion in the application of this minimally invasive technology for this purpose. Endoscopic thoracic sympathectomy (ETS) has been proved to be a safe technique, and the results in hyperhidrosis are rewarding, with a success rate of approximately 95% in most large series**.** ETS is mainly applied for patients with hyperhidrosis however, its use in treatment of other sympathetic disorders, including splanchnic pain, reflex sympathetic dystrophy (RSD) and upper extremity ischemia, is also appropriate when non-surgical treatment fails **(5).**

Equipments and Instruments for Endoscopic Sympathectomy

Learning to Control Endoscopic Tools: Endoscopic surgical tools for sympathectomy, with their extended length and increased weight, require distinct handling techniques. Surgeons control these tools using a two-handed approach, stabilizing them against the chest or abdominal wall for three-point anchoring. The endoscopic video monitor provides a panoramic view of the thoracic cavity, aiding visualization with either a 0-degree or 30-degree endoscope **(6).**

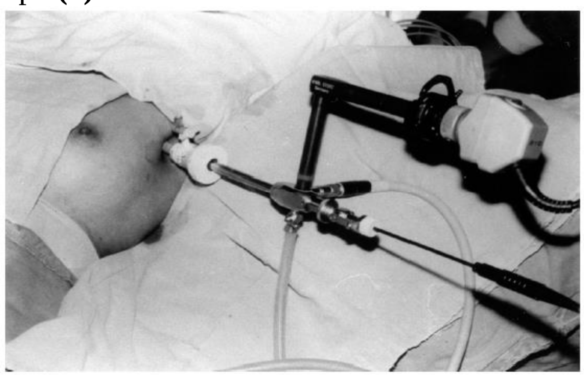

Figure (3): Only one 0.8-cm incision is made for the thoracoscope. Patient was placed in a half-sitting position under single lumen intubational anesthesia

Endoscopic Setup: A single 0.8-cm incision is made for the thoracoscope, and the patient is positioned in a half-sitting posture under single-lumen intubational anesthesia. Electronic devices, a laparoscopic camera, laparoscopic instruments, and forceps are integral components for a successful procedure **(7).**

*I. Electronic Devices (**8**):*

1. Monitoring for laparoscopic image reflection.
2. Xenon light source connected to the laparoscopic camera.
3. Irrigation suction device.
4. Endoscopic carbon dioxide insufflation unit.
5. Monopolar electrocautery.
6. Video recorder on a universal video trolley and video printer.
7. Optional: Harmonic scalpel and Ligasure.

II. Endoscopic Camera: Rigid laparoscopic camera with a 30° scope for a panoramic chest view **(9).**

*III. Instruments and Forceps**:***

1. Three trocars and cannulae (one for the camera and two for working probes).
2. Endograsper (5 mm) for holding the sympathetic trunk.
3. Endodissector (Maryland dissecting forceps) for dissecting and encircling the sympathetic chain.
4. Endoscissor for cutting pleura adhesions and parts of the sympathetic chain.
5. Other instruments: S-Hook, needle holder, dissecting and suture scissors.

IV. Devices for Intraoperative Assessment: Physiological monitoring tools, such as palmar skin temperature, fingertip temperature, infrared thermography, and Laser Doppler Flowmetry, aid in predicting postoperative anhidrosis. These tools help assess blood flow changes, providing valuable insights into the success of the sympathectomy procedure **(10).**

Operative Steps in Endoscopic Sympathectomy

A semi-Fowler's position is preferred with the patient's arms abducted and a roll behind the shoulders to improve access to the upper sympathetic chain. With gravity the lung naturally falls downwards and away from the upper posterior chest wall. Only one 7 mm or 10mm port with an operative-thoracoscope is needed for manipulation. Alternatively, one telescope port and one operating port are placed if an operating thoracoscope is not available. The sympathetic chain is easily identified under the parietal pleura, running vertically over the necks of the ribs in the upper costo-vertebral region **(11)**

Figure (4): Semi-Fowler's position with both arms abducted **(11)**

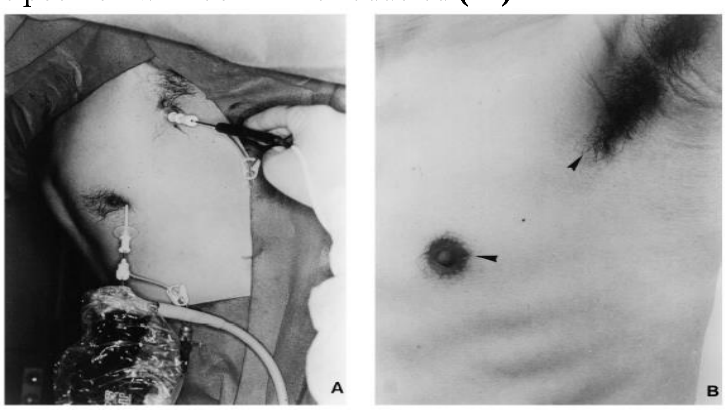

Figure (5): (A) Surgery for sympathicotomy using two instruments. One trocar port is at the areola of a nipple and another is in the axilla. **(B)** Postoperative wound in same patient. Surgical wounds (*arrows*) are hardly visible **(10).**

Bilateral synchronous sympathectomy is performed starting on the right side. An L-shaped hook cautery alternating cutting/coagulation is used to divide the sympathetic chain as this is easier and quicker than attempting to remove a segment of the chain. Special care is taken to make sure that complete ablation of ganglia and severance of the sympathetic chain is achieved. We generally continue the dissection by cauterizing/dividing the pleura for 5 cm lateral to the chain. If an aberrant nerve bundle of Kuntz is identified, it is too severed. The transected ends of the sympathetic chain are separated as far as possible and cauterized to prevent regrowth of the nerve and recurrence of symptoms. For patients with hyperhidrosis, level T_2 and T_3 or T_2-T_5 are divided, depending on the severity of the lower extremity symptoms. It is recommended to do an intervention on the T_2 ganglia for facial hyperhidrosis and rubor, on the T_3 ganglia for palmar hyperhidrosis, and on the T_3 and T_4 ganglia for axillary hyperhidrosis **(12).**

Care should be taken not to divide the sympathetic chain above the level of the second rib for the treatment of palmar and plantar hyperhidrosis, because it increases the risk of Horner's syndrome and contributes little benefit. Thoracic outlet syndrome or reflex sympathetic dystrophy is usually approached at T_1-T_3. For chronic pancreatic pain, we usually divide the sympathetic chain at the level of T_4 to T_{10}. Before closing the skin, a small chest tube is left in the chest and the subcutaneous tissue is closed with 3-0 Vicryl. After expanding both the patient's lungs with positive pressure ventilation, the tube is removed from the chest quickly at positive pressure to avoid a residual pneumothorax, and then a final subcuticular suture is placed. Hence, no thoracic drain is needed postoperatively. The procedure is then repeated on the left side. A chest radiograph is immediately obtained after the operation in the operating room to ensure complete lung expansion. The operation is usually performed in an outpatient setting, and patients are discharged 2 hours after the operation **(13).**

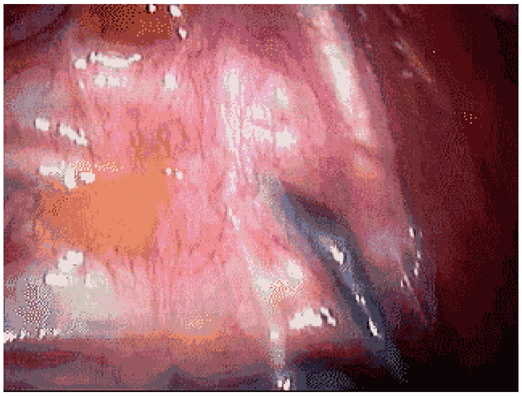

Figure (6): Right sympathetic chain **(9)**

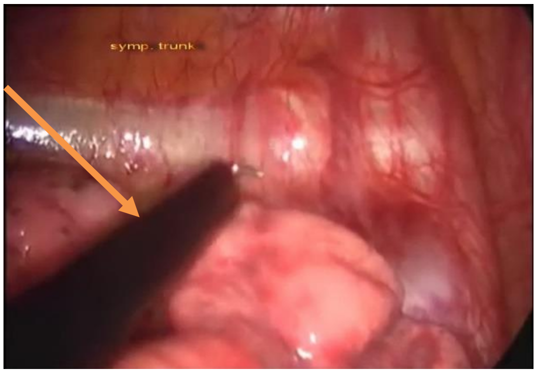

Figure (7): L-shaped hook cautery with the sympathetic trunk **(9)**

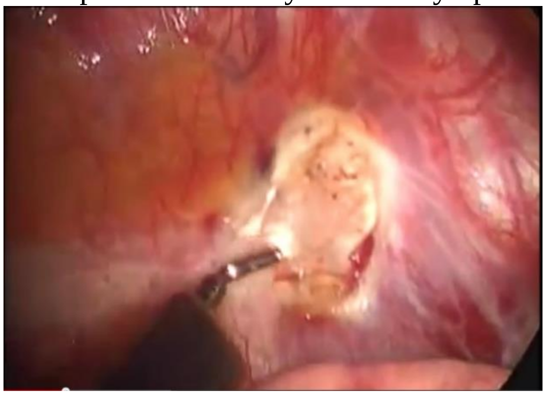

Figure (8): The transected ends of the sympathetic chain **(9)**

Methods of Sympathetic Block:

i. Clamping: Removable Endoclips or "clips" are placed along the sympathetic thoracic chain and ganglia, disrupting nerve transmission, and blocking impulses. Clamps can be removed to restore sympathetic transmission if needed. Compensatory sweating is a potential side effect **(14).**

ii. Cauterization versus Clamping: Clamping can offer similar success and patient satisfaction as cauterization, with the advantage of potential reversal. Removal within six months may be acceptable for a successful result. The clamping method may be advantageous in cases of unhappy patients, allowing for potential reversibility **(14).**

iii. Resection versus Transection:

- **Resection:** Dissecting and removing the sympathetic chain and ganglia, sending the specimen for histological assessment. Higher immediate success rates in terms of dry hands have been reported **(15).**
- **Transection:** Completely dividing the sympathetic chain, a simpler and quicker technique than resection. Ptosis occurs less often after transection. In case of failure, resympathectomy is a valid option **(15).**

Post-operative Care in Endoscopic Sympathectomy

After the patient is awaken and extubated in the operative room, transported to the recovery room. In the recovery room the patients observed that their hands are warm and dry, the patients are observed for any sign of pneumothorax (difficulty breathing and pain on one side) which is uncommon and requires chest tube until the leak resolves. Chest X-ray film is obtained to ensure proper lung expansion and repeated for follow up. The patient spends about two hours in the recovery room, most patients require just an overnight for discharge, but the hospital stay usually one to 2 days. The patient is able to resume his normal activities within few days and return to his work within one week while hard works (sporting activities) can be resumed within 7-14 days post-operative **(16).**

ETS in Hyperhidrosis

With ETS the results are very rewarding in relation to palmar hyperhidrosis, with the disappearance of the symptoms in all cases. Compensatory sweating, the most common side effect usually well tolerated, and the satisfaction index is quite high, so ETS is popular among patients and physicians. Immediate and short-term results of Endoscopic Thoracic Sympathectomy (ETS) for primary hyperhidrosis are excellent. Adverse effects have been identified clearly and are supposed to decrease with time. The excellent results when the operation is carried out for palmar hyperhidrosis and to a less extent for facial blushing and axillary hyperhidrosis. The lower success rate in axillary hyperhidrosis may be due to presence of both eccrine and apocrine glands in the axilla. The eccrine glands are distributed over the entire surface of the skin and innervated by sympathetic fibers but the apocrine glands not innervated by sympathetic fibers and produce milky sweat that contains fat and cholesterol and have strong odor so it continue to function after sympathectomy, and share in the lower success rate **(17).**

Minimally Invasive Posterior Thoracic Sympathectomy

While thoracoscopic sympathectomies are common, some patients with specific conditions may require an alternative, such as those with severe pulmonary disease or morbid obesity. The minimally invasive posterior approach serves as an effective alternative in such cases **(17).**

Advantages:

1. **Bilateral Exposure:** Enables bilateral exposure of sympathetic chains and ganglia in a single operation without intraoperative patient repositioning, avoiding related complications **(18).**
2. **Avoidance of Pleural Entry:** Unlike thoracoscopic approaches, intentional entry into the pleural space is avoided, potentially reducing the risk of hemo- or pneumo-thorax **(18).**
3. **Incorporation into Surgical Repertoire:** Easily integrated into a surgeon's repertoire, particularly if comfortable with minimally invasive spine techniques, akin to the exposure in a thoracic laminectomy **(18).**

*Procedure **(18):***

1. **Patient Positioning:** Placed prone on chest rolls, in head pins, on a radiolucent operating room table.
2. **Incision and Localization:** Skin incisions centered around the T3 costotransverse junction marked via AP fluoroscopy. Bilateral paramedian or midline incisions with fascial openings.
3. **Sequential Dilation:** Overlying costotransverse junction using a K-wire, guided by fluoroscopy.
4. **Fascial Dilation:** Performed at a slight medial angle for visualization of the sympathetic chain beneath the transverse processes.

5. **Retractor Docking:** Tubular retractor docked on the costotransverse joint for endoscopic or microscopic visualization.
6. **Rib Head and Transverse Process Removal:** Utilizing a high-speed drill.
7. **Sympathetic Chain Identification:** Careful dissection to locate the sympathetic chain, assisted by an endoscope if needed.
8. **Hemoclip Ligation and Sectioning:** Above and below the ganglion, confirmed by intraoperative pathological analysis and radiographic placement at T3.
9. **Contralateral Repetition:** Entire process repeated on the contralateral side for bilateral treatment.

Complications of Endoscopic Thoracic Sympathectomy (ETS)

Understanding the complications associated with ETS is crucial due to the age demographic of patients and the perceived nature of the procedure as a 'lifestyle' choice. Patients, particularly those under 30, may face significant social and economic challenges in the event of complications. Given the procedure's characterization as a lifestyle choice rather than a medically necessary intervention, any complication is often considered unwarranted and discouraged **(19).**

Rationale:

1. **Patient Demographics:** The majority of ETS patients are under 30, amplifying the potential impact of complications on their long-term well-being **(20).**
2. **Lifestyle Perception:** ETS is sometimes seen as a lifestyle procedure without clear medical necessity, akin to aesthetic plastic surgery, making any complication undesirable **(20).**
3. **Media Influence:** Media portrayal of ETS tends to highlight benefits while downplaying dangerous complications, potentially misleading patients seeking the procedure **(20).**
4. **Professional Awareness:** Surgeons and anesthetists need to be informed about potential challenges, emphasizing the need for skill acquisition and awareness of pitfalls, especially for the inexperienced **(19).**

Classification of Complications:

I. Intraoperative Complications:

a) Surgical (21):

1. Bleeding (hemothorax).
2. Pneumothorax.
3. Chylothorax.

b) Anaesthetic (21):

1. Respiratory Distress
2. Hypotension
3. Allergic Reactions
4. Anesthesia Awareness

II. Postoperative Complications:

a) Early (Procedure-Related) (22):

1. Lung collapse.
2. Surgical emphysema.
3. Intercostal neuralgia.

b) Late (Sympathectomy-Related) (22):

1. Failure of operation.
2. Compensatory hyperhidrosis.
3. Horner's syndrome.
4. Recurrence.
5. Gustatory sweating.
6. Phantom sweating.
7. Waxy hands and pompholyx.

c) Rare Complications (22):

1. Persistent bradycardia.
2. Brachial plexus injury.
3. Death.
4. Other rare complications.

Compensatory Hyperhidrosis

Compensatory Hyperhidrosis (CH) is the most common and distressing complication for sympathectomy, and it is the "quality marker" of ETS. It is characterized by the postoperative appearance of excessive perspiration in regions of the body where it had not been previously observed **(23).**

Figure (9): Severe compensatory hyperhidrosis of the trunk 3 years after truncal sympathectomy for palmar hyperhidrosis. Note the change in the skin pigmentation in compensatory sweating **(24)**.

Area and percentage affected:

- **Back:** 79%.
- **Chest:** 43%.
- **Groin:** 30%
- **Legs:** 19%.
- **Axillae:** 17%.
- **Trunk:** 7%.
- **Feet:** 3%
- **All body:** 3%

The incidence of compensatory sweating depends on climatic conditions and emotional stress and is higher in warm and humid locations. Compensatory sweating also will be greatly reduced as time goes by and remains stable 6 months after surgery **(25).**

Another definition of severe compensatory sweating:

- **First:** Under the daily activity condition, the need to change underwear more than twice a day.
- **Second:** The timing of the diagnosis for compensatory sweating is 12 months after surgery.

Most patients consider CH as a minor drawback, which is much more bearable than their former condition. However, others find CH troublesome. In some rare cases, CH may be so disturbing that patients ask for reconstruction of the sympathetic chain**.** Despite of its high incidence, there is no effective way to avoid it. Compensatory sweating is greater with extensive sympathectomy (to the level of T_4 or T_5) resection, it increases with resection of a number of more than two ganglia especially by electrocautery. **(26).**

Pathophysiology

This phenomenon is caused by a temperature regulating compensatory mechanism in the body and is correlated with the extent of sympathectomy. That is the greater the number of glands removed from thermoregulatory control, the greater is the response anticipated from the remaining glands. The residual trunk glands will take over to compensate for the lost area. Patients with a clamp or nerve graft reversal show redistribution of sweat toward the upper body and face. It may be that as the head area starts sweating again, it provides some cooling effect and thus a reduction in the compensatory sweating. Anatomically, the sympathetic nerves originate in the intermediolateral horns of the spinal cord, between segments T_1 and L_2. Each sympathetic pathway is composed of preganglionic and postganglionic neurons. The nerve fibers to the sweat gland are postganglionic fibers arising from the ganglion on the sympathetic trunks. These fibers re-enter the corresponding spinal nerves along its grey ramus communicans. Also, they may go upward and downward in the sympathetic trunks before leaving and distributing to the sweat gland. Therefore, the distributions overlap, and are not necessarily to the same part of the body from the same spinal segments. Moreover, visceral afferent fibers are accompanied by visceral efferent fibers. It has been demonstrated that the autonomic nervous system functions the same as the neuroendocrine system, through positive and negative feedback mechanisms. Impulses initiated in the target organs (e.g. sweat glands) are transmitted as an afferent negative feedback signal to the central nervous system, from where the efferent positive feedback signals return to the target organs. We know that hyperhidrosis is induced centrally by mental stress or anxiety rather than by high temperature. These factors often trigger sweating centers located in the hypothalamus, releasing efferent signals, which are positive in a sympathetic tone to the target cells or organs. As with the neuroendocrine system, some sympathetic tones return from the target organs and then become afferent negative feedback signals to the hypothalamus **(27).**

Then a magnified efferent positive feedback signal is released from the sweating center, inducing severe sweating on the body or lower limbs. It never occurs on the upper body or face because the efferent sympathetic tone never reaches the hands or face again (due to blockage of the nerve). The same mechanism can be applied to T_3, T_4, and so on. In contrast to the T_2 block, whose afferent negative feedback signals are mostly destroyed, the T_3 or T_4 procedure preserves some negative feedback signals returning to the hypothalamus. *The term ‘‘reflex sweating’’ is more accurate than‘‘compensatory hyperhidrosis, which is a misused medical term.* Changes in sweating patterns after sympathetic surgery may be attributable to a reflex response in the sweating center of the hypothalamus, and not at all to a compensatory mechanism **(28).**

First: Different degrees of postoperative sweating have been found after different levels of sympathectomy. For example, severe reflex sweating is expected with the T_2 procedure, whereas an unknown amount or no reflex sweating is found with the T_4 procedure **(29).**

- **Second:** Sweating problems can be induced after sympathetic surgery for nonsweating sympathetic disorders. The typical example is pure facial blushing. Severe reflex sweating often is induced after the T_2 procedure **(30).**
- **Third:** No change in sweating patterns was found after lumbar sympathectomy. That is, after the procedure, the soles became dry, but sweating did not change in other areas of the body **(30).**
- **Fourth:** The amount of increased sweating does not always correspond to the amount reduced after sympathetic procedures **(30).**

Prevention

1- **Preservation of T_2 ganglion:** The higher the interruption or resection in the sympathetic chain was performed, the more afferent fiber responsible for inhibiting sudoresis would be damaged, thereby causing a considerable increase in quantity and severity of compensatory sweating. Compensatory sweating was less prevalent among patients who underwent T_3 and T4 ganglion resection than among patients with T_2 ganglion ablation. Presently, it seems that the T_3 ganglion is the key ganglion for sympathetic denervation of the upper extremity **(31).**

2- **ETS by clipping:** The clipping method is strongly recommended because of its reversibility **(26).**

Operating on the dominant hand alone seems to reduce CH. Compensatory sweating especially may be severe enough to cause the patient to regret the surgery. The overall satisfaction rate is dependent on the magnitude and impact on the quality of life of the problem solved by ETS (**32**).

Prediction of compensatory Hyperhidrosis:

Postoperative compensatory hyperhidrosis happens in 50–90% of patients with no effective treatment for postoperative compensatory hyperhidrosis after definite sympathectomy. Local sympathetic block can be done either in an ultrasound (US)-guided manner, in a computed tomography (CT)-guided manner, or thoracoscopically. The US-guided and CT-guided approaches are less invasive than the thoracoscopic approach**.** Temporary sympathetic blocks, such as chemical or thermal blocks, provide a reversible means of interrupting the sympathetic nervous system's activity, allowing clinicians to observe the potential compensatory effects without irreversible surgical interventions **(26).**

Furthermore, this predictive approach allows for a more personalized and patient-centred treatment plan. Clinicians can tailor the extent of sympathectomy based on the individual's tolerance and susceptibility to compensatory hyperhidrosis, thus minimizing the risk of postoperative dissatisfaction. Additionally, the temporary nature of the intervention ensures that any adverse effects are reversible, providing a safety net for both patients and healthcare providers **(33).**

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