# Endoscopic Thoracic Sympathectomy

Eleni Moraites, MD[a], Olushola Akinshemoyin Vaughn, BA[b], Samantha Hill, MD[c,*]

**KEYWORDS**

• Hyperhidrosis • Endoscopic thoracic sympathectomy • Palmar hyperhidrosis
• Axillary hyperhidrosis • Quality of life

**KEY POINTS**

- Endoscopic thoracic sympathectomy is a useful surgical approach in the treatment of selected patients with severe palmar hyperhidrosis.
- Approaches used to interrupt the sympathetic signal to the sweat glands include cutting or clipping the sympathetic chain.
- Ideal candidates for endoscopic thoracic sympathectomy are patients with onset before 16 years of age who are younger than 25 years at time of surgery, have body mass index less than 28, report no sweating during sleep, and have no significant comorbidities.
- Patients should be informed that endoscopic thoracic sympathectomy is associated with a high rate of the development of compensatory hyperhidrosis and that reversal procedures are unlikely to improve compensatory sweating.

## INTRODUCTION AND HISTORY

The sympathectomy, a surgical procedure creating a break in the sympathetic signaling pathway, was pioneered in 1889 and at the time was used to treat conditions such as epilepsy, exophthalmic goiter, idiocy, and glaucoma. Although no longer indicated to treat these conditions, more advanced versions of the sympathectomy have found a place in the treatment of hyperhidrosis.[1] Hyperhidrosis is a skin disorder characterized by sweating in excess of what is necessary for thermoregulation of the body. This excessive sweating often involves the craniofacial region, axillae, palms, or soles and can be classified as either primary, which is idiopathic, or secondary to a medical condition or medication. Hyperhidrosis can be further classified as focal, regional, or generalized, with most patients suffering from primary focal hyperhidrosis. Various treatment modalities for the condition exist, including localized topical and injectable treatments, systemic medical treatments, and several surgical treatments.[2] The focus of this article is endoscopic thoracic sympathectomy (ETS) as management for primary focal hyperhidrosis.

Today the main indications for the sympathectomy are blushing, flushing, and hyperhidrosis.[1] Because hyperhidrosis is thought to potentially be caused by excessive sympathetic stimulation, the intention of ETS is to interrupt that signal by cutting or clipping the involved sympathetic nerves.[2] The procedure is noted to have particular success in the improvement of palmar hyperhidrosis.[3] Initially, the sympathectomy was an open procedure, but it has evolved into an endoscopic surgical technique.[1] The main goal over time has been to maintain efficacy while minimizing the invasiveness of the procedure in an effort to reduce the

Financial Disclosures: There are no financial disclosures to report for any of the authors.
[a] Hennepin County Medical Center, 701 Park Avenue, Minneapolis, MN 55415, USA; [b] School of Medicine and Public Health, University of Wisconsin-Madison, 750 Highland Avenue, Madison, WI 53705, USA; [c] RidgeView Dermatology, 101 Candlewood Court, Lynchburg, VA 24502, USA
* Corresponding author.
*E-mail addresses:* hillsa1@gmail.com; sehill@ridgeviewdermatology.com

Dermatol Clin 32 (2014) 541–548
http://dx.doi.org/10.1016/j.det.2014.06.007

risk of complications, specifically the development of compensatory sweating.[1,4]

## ANATOMY AND PHYSIOLOGY

The sympathetic nerves that control sweating originate in the spinal cord between segments T1 and L2. The distribution is segmental and variable, with sympathetic fibers from T1 generally supplying the head, T2 the neck, T3 to T6 the thorax, T7 to T11 the abdomen, and T12 to L2 the legs.[5,6]

Experiments performed in the 1950s found that most of the sympathetic outflow to the hand originates from T2 to T3.[7] Signaling from these levels may also travel via an alternative pathway, the nerve of Kuntz. Although not present in all people, the nerve of Kuntz forms a connection from the second intercostal nerve to the first thoracic ventral ramus, allowing signals to reach the brachial plexus without traversing the sympathetic trunk.[8] Therefore, complete denervation of the hand requires surgical division of the sympathetic chain above the T2 ganglion and below the T3 ganglion as well as possible transection of Kuntz's nerve.[5] When axillary hyperhidrosis exists with palmar hyperhidrosis, surgery may be extended to include the T4, T5, or even T6 ganglion.[6,9] The cervicothoracic ganglion, or stellate ganglion, is formed by the fusion of the inferior cervical ganglion and the first thoracic ganglion. It has been implicated in hyperhidrosis but is often left untouched during ETS to avoid Horner's syndrome.[10] More specific information regarding these techniques will be addressed in a later section of this review.

Endoscopic lumbar sympathectomy is has been used for plantar hyperhidrosis. Sympathetic outflow to the lower extremities originates at T12, L1, and L2 and, therefore, can be interrupted by division of the sympathetic trunk at the L3 level or removal of the ganglia from L2 to L4.[6] In surgery, the first lumbar ganglion often is left untouched in an attempt to preserve sexual function.[6]

## NOMENCLATURE

Various terms have been used to describe origins of sympathetic innervation with regard to the exact location of surgical intervention. Some authors describe the vertebral level (T), whereas others describe sympathetic outflow by its relationship with the nearest rib (R). Recently, the International Society on Sympathetic Surgery and The Society of Thoracic Surgeons General Thoracic Task Force on Hyperhidrosis acknowledged the need for uniform language to describe the location of ETS in an effort to make comparisons between procedures more accurate.[2] A consensus on terminology, as determined by International Society on Sympathetic Surgery and the Society of Thoracic Surgeons in 2011, indicates that standard nomenclature using rib orientation is the most precise way to describe ETS. An operative note would describe the procedure by noting the rib number (for example, R3 is the third rib) and the location (top, bottom, or both) where the denervation occurred relative to the rib.[2] For example, a procedure at R4, above denotes nerve interruption above the fourth rib. Both R and T nomenclature, including the use of R nomenclature without the denotation of above and below, are used in the literature and are so used in this report.

## INDICATIONS

Referral for ETS may be indicated when medical therapies and, when appropriate, local surgery have failed or are contraindicated. Other treatments for axillary hyperhidrosis include topical antiperspirants such as aluminum chloride; injected botulinum toxin; oral anticholinergic medications; and local surgeries including simple excision, curettage, and liposuction and procedures that combine these techniques.[9] More recently, microwave and ultrasound technologies have also been used to treat axillary hyperhidrosis. For palmar hyperhidrosis, standard treatments include topical aluminum chloride, oral anticholinergic medications, iontophoresis, and botulinum toxin. For craniofacial hyperhidrosis, treatments include topical aluminum chloride, botulinum toxin, and oral medications such as anticholinergics, clonidine, propranolol, and diltiazem.[9,11] The algorithm for treatment strategies in plantar hyperhidrosis is similar to that of palmar hyperhidrosis, with ultimate referral for endoscopic lumbar sympathectomy rather than thoracic sympathectomy.[9,12]

Based on randomized trials and nonrandomized comparisons, the Society of Thoracic Surgeons has described an ideal candidate for ETS[2]:

- Patients with onset before 16 years of age who are younger than 25 years at time of surgery
  - with body mass index less than 28
  - reporting no sweating during sleep
  - without significant comorbidities and
  - with resting heart rate greater than 55 beats per minute.

Additional indications for ETS include[1]:

- Arteriospastic disorders: eg, Raynaud's disease and acrocyanosis
- Occlusive arteriolar disorders: eg, thrombongiitis obliterans

- Some neurologic disorders: eg, posttraumatic sympathetic dystrophy
- Intractable pain: eg, angina and complex regional pain syndrome
- Possibly social phobia

Selection criteria for randomized trials exploring surgical treatment of hyperhidrosis frequently include only severe and debilitating primary palmar hyperhidrosis with serious negative repercussions on social life and professional activity.[13,14] According to the Society of Thoracic Surgeons Expert Consensus, "only a small percentage of patients should be considered for surgical treatment."[2]

## TECHNIQUES

The goal of a sympathectomy of any kind for hyperhidrosis is to disconnect the eccrine sweat glands from the sympathetic signals that trigger them to initiate sweating. Initially, open procedures were performed, with approaches including anterior supraclavicular, posterior paravertebral, posterior midline, anterior thoracic, axillary thoracic, or axillary extrathoracic with first rib resection.[15] In 1951, Kux first described an endoscopic transthoracic approach, and this technique is now the standard of care for hyperhidrosis.[4]

Current techniques involve the destruction of the bilateral thoracic sympathetic ganglia via endoscopic resection, ablation, or clipping (**Fig. 1**).[2,16] The procedure requires general anesthesia, but most patients are able to go home the day of the procedure. There are reports of the use of local anesthesia for the procedure, but this is not generally recommended.[2,16]

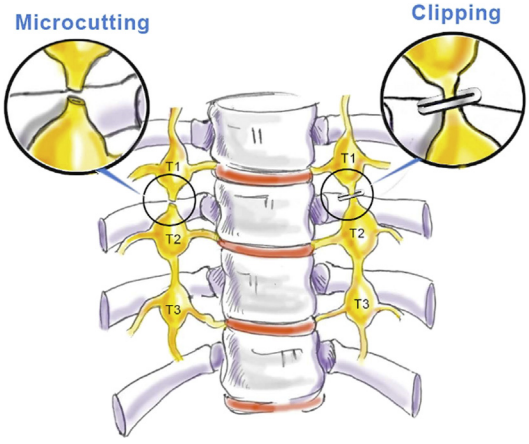


**Fig. 1.** Current techniques for endoscopic thoracic sympathectomy. (*Courtesy of* Albert Ganss, International Hyperhidrosis Society, Quakertown, PA; with permission.)

Surgical technique can vary based on surgeon preference and anatomic location of hyperhidrosis. Recent consensus recommendations from the Society of Thoracic Surgeons are to interrupt the sympathetic chain above the third rib for palmar hyperhidrosis, above the fourth and fifth rib for axillary hyperhidrosis, and above the third rib for craniofacial hyperhidrosis (**Table 1**).[2]

Traditionally, for isolated palmar hyperhidrosis, an incision of less than 1 cm is made in the midaxillary line, through which the endoscope and instruments are inserted. Carbon dioxide insufflation may be used to partially collapse the lung, improving visualization. The anatomy is examined, and the sympathetic chain is divided, often just above T2 and below the stellate ganglion.[4,17] Additional sites may be interrupted, including other ganglia and nerves of Kuntz if present. The ends of the nerves are separated to allow at least a 1-cm gap to reduce nerve regrowth and recurrence of hyperhidrosis. Sympathetic tone to the hand is assessed with a laser Doppler palmar blood flow device or finger temperature probe. A suction catheter is used to evacuate the pneumothorax if the lung has been collapsed; otherwise, intrapleural air is aspirated through tubes. A chest x-ray is obtained after the procedure to ensure proper lung inflation and minimal intrapleural air. The procedure generally takes less than an hour to complete.[4,17]

Researchers have attempted to analyze whether transection, resection, ablation, or clipping is a superior technique in ETS. No clear differences have been found.[2,18] Rather, the results are dependent on whether the correct level of division was achieved and if there was enough separation between the ends of the chain to avoid nerve regrowth.[2]

A few small prospective studies out of China have recently found an effective new technique using a transumbilical endoscopic approach to achieve thoracic sympathectomy. In one study,

**Table 1**
**Society of Thoracic Surgeons consensus**

| Location of Hyperhidrosis | Recommended Surgical Level |
|---|---|
| Palmar hyperhidrosis | Above third rib (driest palms) or above fourth rib (palms less dry but reduced chance of compensatory sweating) |
| Axillary hyperhidrosis | Above fourth and fifth rib |
| Craniofacial hyperhidrosis | Above third rib |

66 patients with severe palmar hyperhidrosis presented for thoracic sympathectomy.[19] Thirty-four of these patients received transumbilical thoracic sympathectomies through a 5-mm umbilical incision using an ultrathin gastroscope; the remaining patients were treated with traditional needlescopic thoracic sympathectomy.[19] All of the patients reported that the procedure successfully treated their hyperhidrosis. Patients receiving the transumbilical procedure reported reduced pain and paresthesia; this is possibly explained by the absence of a chest wall incision and subsequent lack of manipulation of intercostal space with trocars. This transumbilical technique showed a superior aesthetic outcome when compared with the traditional group, although the operating time of the surgery was slightly longer.[19]

Use of a voice-controlled robotic arm has been compared with use of a human camera-holding assistant.[20] There was no difference between groups in terms of accidents, pain, general satisfaction, anhidrosis, length of hospitalization, or compensatory hyperhidrosis (CH). The robotic group had reduced contact of the laparoscopic lens with mediastinal structures but also had longer operating time, suggesting that the robotic camera is as safe as a human assistant but less efficient.[20]

## OUTCOMES

The ETS procedure is thought to relieve palmar hyperhidrosis in greater than 95% of patients.[21] Recurrent sweating develops in 0% to 65% of patients that undergo the procedure.[2] Compensatory sweating occurs in up to 98% of patients.[2] Patient satisfaction is reported to be between 66.7% and 93% but is known to decline with time.[22]

Four main studies show the trends in satisfaction and complication rates of ETS.

### *Unilateral or Bilateral ETS*

A 1994 study followed up with 270 patients who had unilateral or bilateral ETS for upper extremity hyperhidrosis, with a total of 480 sympathectomies.[23] Patients who had undergone ETS between 1965 and 1992 were sent a questionnaire regarding early postoperative results, side effects, complications, and long-term effects of the procedure; the average time between the procedure and receipt of the questionnaire was 16.4 years, ranging from 9 months to 27.1 years.[23] Results from the questionnaire indicate treatment failure in 1.9% of cases and symptom recurrence in 1.5%. A total of 95.5% of patients were initially completely satisfied, 66.7% were completely satisfied at follow-up, and 26.7% were partially satisfied. Reported side effects include compensatory sweating (67.4%), gustatory sweating (50.7%), severe dryness of the hands (<1.2%), and Horner's syndrome (2.5%).[23]

### *Bilateral ETS*

In 1995, Drott and colleagues[24] followed up with 850 patients for 31 months after bilateral ETS for upper extremity hyperhidrosis. Treatment failure was reported in 2% of patients with symptom recurrence in 2% of patients. 98% reported satisfactory results at the end of follow-up. Compensatory sweating occurred in 55% of patients, with 2% considering this as disturbing as their original symptoms.[24] Gustatory sweating occurred in 36% of patients, but was often relieved with anticholinergic drugs and not considered a major problem by patients. The use of anticholinergic medications to treat other forms of compensatory sweating was not discussed. Three patients developed Horner's syndrome, one of which was temporary.[24]

More recently, a 2013 study followed up with 51 patients for up to 16 years.[25] The investigators reported treatment failure in 2% of patients; recurrence rate was not discussed. A total of 86.3% of patients rated their satisfaction as excellent or good, and 9.8% were not happy. Of the not happy, 3 suffered postoperative chest pain, one had a pneumothorax and empyema leading to prolonged hospital stay, and one had treatment failure.[25] A total of 97.4% of patients experienced compensatory sweating. Patients with compensatory sweating located on the back rather than face, axilla, abdomen, thighs, or feet were more likely to rate satisfaction as excellent or good.[25]

### *Gender Differences in Outcomes of ETS*

Finally, a 2010 study analyzed gender differences in outcomes of ETS by surveying 1044 patients, 719 women and 325 men, who underwent surgery for palmar hyperhidrosis from 2000 to 2008.[26] Treatment failure was reported in 1.2% of patients, regardless of gender, but overall recurrence rate was not discussed. In a survey 30 days after surgery, there were no significant differences in quality of life reported between genders.[26] Overall, 95% of patients reported that their quality of life was either better or much better, and 1.5% claimed their quality of life was a little worse or much worse. Results indicating perceived postsurgical differences in quality of life were similar for both genders.[26]

### *Outcomes Variances*

Outcomes are highly dependent on the level of interruption of the sympathetic chain. Recent

literature compared multiple-level sympathectomy with single ganglia ETS. Meta-analysis suggests that there is no significant difference in efficacy between groups.[27] However, one study found that clipping above and below T4 improved efficacy and lowered the risk of compensatory sweating when compared with T2 to T4 sympathectomy.[28] For palmar hyperhidrosis, the Society of Thoracic Surgeons consensus document suggests that 2 interruptions are made, at R3 and R4, for patients who are willing to accept a higher risk of CH to have completely dry hands. R3 or R4 interruption alone may be appropriate to limit the likelihood of CH, although it may result in moister hands.[2]

Additional studies have sought to further compare the efficacy of single ganglia ETS at different levels for palmar hyperhidrosis, with one showing improved effectiveness at R3 (above the third rib, usually T3) when compared with R2 (above the second rib, usually R2). This study found that treatment failure was more common with R3 sympathecotomy, but the persistent palmar hyperhidrosis could be cured with reoperation at the R2 level.[29]

Finally, preoperative characteristics may be predictive of poor postoperative results. Younger age, male sex, and higher levels of preoperative and postoperative sweating may predict treatment failure, whereas increased age may correlate with increased CH after surgery.[29]

## VARIATION IN OUTCOMES BY ANATOMIC LOCATION OF HYPERHIDROSIS

The outcomes of ETS vary based on the anatomic location of the sweating. Patients undergoing operation for palmar hyperhidrosis tend to be more satisfied than those with axillary hyperhidrosis, at 46.2% and 33.3% respectively.[23] Recurrence rates may be dramatically different between palmar and axillary hyperhidrosis, with one study finding recurrence rates of 6.6% for palmar hyperhidrosis and 65% for axillary.[30]

Patients with palmar hyperhidrosis often have concomitant plantar hyperhidrosis, so the optimal treatment strategy for patients with palmoplantar hyperhidrosis has been analyzed. In one study, 73 patients were treated for hyperhidrosis with an endoscopic thoracic sympathetic block, 66 of whom had both palmar and plantar hyperhidrosis. The study showed that 100% of patients had nearly or completely dry palms after an endoscopic thoracic sympathetic block with a clip placed at T4, and 50% of the patients showed relief from plantar sweating, although the mechanism for this improvement is unclear.[31] For patients with palmoplantar hyperhidrosis, additional interruption at R5 may be superior to sympathectomy at R4 alone,[2] but some clinicians note that long-term results tend to be poor.[12] Plantar hyperhidrosis may be more tolerated than other forms of hyperhidrosis because excessive sweat on the feet is easier to conceal and is often considered more socially acceptable than excessive sweating in other areas of the body.

ETS is used for craniofacial hyperhidrosis in cases of clinical severity.[9] It is critical to distinguish isolated craniofacial hyperhidrosis from facial blushing. Facial blushing is best treated with T2 sympathectomy,[32] whereas craniofacial hyperhidrosis is best treated by R3-alone interruption.[2] By one analysis, patients with facial hyperhidrosis were more likely to be either satisfied or regret having the procedure as opposed to patients with facial blushing, who were most likely to say they were very satisfied after surgery. All patients in this study had ETS at R2, R2 to R3 or R2 to R4.[33]

## COMPLICATIONS

ETS is an elective procedure that has great potential benefits but also some significant risks. Patients having this procedure are often greatly distressed by the social and occupational limitations that are often associated with hyperhidrosis and must be well informed before electing to have this procedure.[2] Also, because most patients that have this procedure are less than 30 years of age, it is important to consider that these individuals in whom complications do arise may have many years of suffering after the procedure.

Potential complications from ETS include[30,34–37]:

- Development of Horner's syndrome: 1%–2.5%
- Pneumothorax: 7%
- Hemothorax: 1%
- Paresthesia: up to 50%
- Compensatory sweating: >50%
- Hyperthermia
- Bradycardia requiring a pacemaker

A literature review of the complications of ETS was performed in 2004 looking for patterns of potentially significant drawbacks to having the procedure; this was a Medline search using terms "*thoracoscopic sympathectomy*, *endoscopic thoracic sympathectomy*," and *complications*.[38] Results of the review show that the most common short-term complication of the procedure is a spontaneously resolving postoperative pneumothorax. Approximately 5% of patients have significant intrathoracic bleeding but only a minority will go on to require a thoracotomy to

correct this problem. An extremely common long-term complication is compensatory sweating. Ojimba and Cameron[38] reported 1% to 2% of patients regretted having the procedure because of the severity of the compensatory sweating.

A more recent analysis of 1731 cases indicates that the most common immediate postoperative complication is pain (97.4%) and estimates the late complication of compensatory sweating at 88.4%.[39] Immediate postoperative complications also include pneumothorax (3.5%), neurologic disorders of the upper limbs (2.1%), Horner's syndrome (0.9%), significant bleeding (0.4%), and extensive subcutaneous emphysema.[39]

Although there are no published known deaths from ETS, anecdotally there are 9 known deaths after ETS resulting from severe hemorrhage or complications from anesthesia.[38]

## COMPENSATORY SWEATING

Of all the known risks associated with ETS, it is perhaps most important for the patient to understand the risk of compensatory sweating. Compensatory sweating, also called compensatory hyperhidrosis (CH), occurs when treatment for hyperhidrosis decreases or eliminates sweating in the original problem area, but the body then compensates by increasing sweat production in another remote location.[2,38] CH is the most common side effect of ETS, and literature cites that CH develops in anywhere between 3% and 98% of patients.[2] This wide range may be accounted for by varying definitions of CH and variations in the surgical approach for treatment of hyperhidrosis. The most common sites for CH occurrence are abdomen, back, legs, and gluteal area.[40] Adult patients and those who have a preexisting tendency to sweat in the inguinal folds, buttocks, back, and upper thighs are at greater risk for CH.[2,41] Pediatric patients and those undergoing a single ganglion transection not involving T2 report the lowest rates of CH.[41]

Most studies do not quantify the level of severity of compensatory sweating, but a 2009 study sought to measure severity using patient questionnaires.[41] Severity was measured on a 10-point scale, with 10 being unbearable and 0 being no symptoms, and was assessed at each site of compensatory sweating. Overall, compensatory sweating rated 4.5 in severity and was most commonly found in the back, abdomen, chest, legs, and thighs. Age was the only independent predictor of CH in multivariate analysis, whereas age and multilevel sympathectomy were independent predictors of a high severity score. Operation on T2 and high severity score were independent predictors of patient dissatisfaction.[41]

The current trend with regard to limiting the possibility of compensatory sweating is performing a sympathectomy at T4 alone.[2,40] Several studies found that this technique may reduce the risk of compensatory sweating greatly. In one study of 276 patients with axillary hyperhidrosis, 78.3% underwent thermal ablation of T3/T4, whereas 21.7% had thermal ablation of T4 alone. The study indicated that the T4 group reported higher satisfaction rate, lower recurrence rate, and lower severity of compensatory sweating.[40] A meta-analysis of studies published in the last decade indicated that T3 sympathectomy is recommended for the treatment of palmar hyperhidrosis regardless of the surgical technique used.[27]

## QUALITY OF LIFE

Although compensatory sweating may arise after ETS, it is important to determine if quality of life is improved regardless of complications. A 2012 study of the evolution of quality of life over 5 years in 453 patients who had ETS found that patients had immediate and sustained improvement in quality of life over the course of the study.[42] This was a prospective, nonrandomized and uncontrolled study carried out via questionnaire regarding quality of life following ETS. The questionnaire was given perioperatively, at 30 days, and at 5 years after the procedure. The study found that 97.3% of patients had complete remission of palmar, axillary, or facial sweating after 5 years. Those who did have an improvement in quality of life from ETS had sustained improvement over 5 years. Although 71.5% of patients reported moderate-to-severe compensatory sweating, only 1.5% of patients were dissatisfied with the results of the procedure.[42]

The factor that most influences postsurgical quality of life is compensatory sweating. Therefore, patients should be informed of this side effect, and treatment should be tailored to reduce compensatory sweating based on anatomic location and patient preferences.[2,43] In general, higher levels of blockade on the sympathetic chain correspond to higher regret rates. Patients should also be made aware that the most satisfied patients are those with palmar or palmar-axillary hyperhidrosis, or both.[2] Another significant factor is the recurrence of symptoms after ETS. Recurrence of hyperhidrosis after surgery has been reported with incidence of between 0% and 65%; the variability may be explained by use of different

surgical techniques, level of sympathetic interruption, and durations of follow-up care.[2] If recurrence of hyperhidrosis occurs, it usually recurs within 18 months of surgery.[21]

## REVERSAL

In some instances, the CH after ETS is severe enough to warrant attempt at surgical reversal. Techniques of reversal include unclipping and nerve grafting. Surgical clips can be used instead of surgical, thermal or ultrasonic ablation with the theoretic advantage of allowing reversal if the patient develops intolerable compensatory sweating. However, because permanent and irreversible perineural damage may occur to a nerve following the application of a clip, removal may not always result in return of sympathetic tone to the preoperative state.[2,44,45] In a 2009 study of thoracoscopic clipping for hyperhidrosis, 4.7% of the participants later underwent a reversal procedure for the development of CH. Of these patients, 48% reported a significant decrease of CH and 42% reported that the sweating at their original problem site remained controlled.[45] 68% of patients having a reversal within 6 months of the initial procedure reported substantial decrease in CH, versus 37% reporting substantial decrease in CH with a reversal procedure at greater than 6 months.[45]

## SUMMARY

ETS is an effective surgical treatment for palmar, axillary, palmoplantar, and craniofacial hyperhidrosis, with reproducible improvement in more than 94% of patients.[2] Although initial immediate satisfaction rates are very high, patient satisfaction may decrease over time. This is mainly because of compensatory sweating, which occurs in many patients and can be a significant and bothersome problem that can decrease quality of life. Although surgical technique may reduce incidence of compensatory sweating and other side effects, patient characteristics such as anatomic location of sweating, age, body mass index, symptomatology, and comorbid conditions must also be taken into account. Selection of ideal surgical candidates using these parameters is key to the success of the surgery.[2] Patients must be made aware of not only the perioperative risks and benefits but also the long-term risks and benefits of this procedure.

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