ENDOSCOPIC THORACIC SYMPATHECTOMY FOR HYPERHIDROSIS

Executive Summary

Background Information: Hyperhidrosis is a condition in which sweat production exceeds that which is needed for thermoregulation, and can affect the hands, feet, axilla, face, back, groin, or legs. Primary hyperhidrosis is characterized by increased sympathetic activity at the upper thoracic ganglia T2 and T3 with no apparent underlying cause. Hyperhidrosis can also occur secondary to underlying neurological or systemic disease. Although not a dangerous condition, hyperhidrosis can ruin clothing, cause social and occupational impairment and emotional distress, and facilitate the development of secondary morbidity. Conservative treatment for hyperhidrosis often begins with the use of topical aluminum chloride, however, aluminum salts can cause skin irritation and intense itching. Other noninvasive treatments include iontopheresis, which requires repeated treatments of the affected region, and oral anticholinergics and beta-blockers, which have numerous side effects, such as nausea, dizziness, blurred vision, and dry mouth. Recently, a number of studies have demonstrated that injections of botulinum toxin in the affected region can reduce excessive sweating, likely through blocking presynaptic release of acetylcholine. However, the effect is temporary, and repeated injections are necessary.

Although these treatments are often effective in milder cases, patients with severe hyperhidrosis often remain symptomatic and sometimes require surgical intervention. The goal of surgery for hyperhidrosis is to disrupt the sympathetic supply to sweat glands by destroying relevant ganglia in the upper thoracic sympathetic chain. Upper thoracic sympathectomy is designed to reduce palmar, axillary, and more rarely craniofacial sweating, but is not intended to treat plantar hyperhidrosis. Although sympathectomy is sometimes performed as an open procedure, most current techniques involve a limited sympathectomy that is performed endoscopically. Endoscopic thoracic sympathectomy (ETS) involves resection or ablation of the T2 ganglion for palmar hyperhidrosis, and resection of the 3rd and 4th ganglia for patients with axillary hyperhidrosis.

Findings: Evidence evaluated for this report was obtained primarily from a search of the peer-reviewed literature published between 1985 and December 2002. All ETS studies using comparison groups were selected for review, as well as case series studies with at least 100 patients. Almost all of the studies evaluating ETS were case series, some very large and a few with long-term follow-up on at least some of the patients. Only one study was randomized; this was a small study that compared operative parameters and short-term results in patients randomized to either open supraclavicular sympathectomy or thoracoscopic sympathectomy. Many of the studies were from Taiwan, South Korea, and Israel, reflecting the relatively high frequency of hyperhidrosis in these countries. Although none of the studies were controlled, most involved patients who had failed previous nonsurgical therapies. Outcome measures were largely subjective, primarily involving assessment of efficacy and patient satisfaction using a questionnaire sent to the patient at some time following surgery. Follow-up times varied, ranging from 1 month to several years, with one study providing follow-up data for 8 years on some patients.

The one small, randomized study that compared postoperative results following open or endoscopic sympathectomy found that operative times were shorter, hospital days less, and patient satisfaction higher after the open procedure compared with the endoscopic procedure. However, this was an early study, and it is likely that the endoscopic technique used at that time was not as highly refined as those currently in use.

One large case series involved a technique of stereotactic percutaneous thermocoagulation of the upper thoracic sympathetic ganglia, while the other studies used various methods of ablation, resection, or clipping under direct endoscopic or video guidance. The results of these studies indicate that minimally invasive sympathectomy, performed either endoscopically or percutaneously, can provide relief from palmar or axillary hyperhidrosis in the majority of patients, with some efficacy for craniofacial and plantar hyperhidrosis. Reported success rates ranged from 67% to 100% for treatment of palmar hyperhidrosis, which was the most common site treated.

Success rates for axillary hyperhidrosis were somewhat lower than for palmar hyperhidrosis, ranging from 33% to 75%. Three studies included patients with craniofacial hyperhidrosis, who reported 95% to 100% satisfaction with the outcome. One study also reported a decrease in plantar sweating in 92% of patients, although plantar hyperhidrosis was not the primary indication for surgery. Another study examined recurrence of symptoms after sympathectomy, reporting a 5-year recurrence rate of 13% for palmar hyperhidrosis, and 17% for axillary hyperhidrosis.

Compensatory hyperhidrosis was very common following sympathectomy, with 44% to 86% of patients reporting this sequela, which was generally more severe after T3-T4 sympathectomy. Some studies also reported gustatory sweating following sympathectomy. Other complications were relatively rare, with few serious adverse events reported. Pneumothorax occurred in up to 4.6% of patients in some studies, while Horner's syndrome was reported in between 0.2% and 2.5% of patients. Postoperative complications included pain, bleeding, pleural effusion, and subcutaneous emphysema; however, the incidence of these adverse events was low.

Definitive patient selection criteria for ETS as a treatment for primary hyperhidrosis have not been established. However, there is sufficient evidence from large case series studies, some with long follow-up, to support the use of ETS for patients with primary palmar hyperhidrosis that is severe enough to cause social, psychological, or work-related disability, and that has been unresponsive to appropriate nonsurgical therapies.

Contraindications for ETS include pleural adhesions, which can make accurate identification and dissection of the sympathetic ganglia difficult, and any underlying condition that would pose a danger to the patient in the presence of pneumothorax.

Conclusions: Evidence from a number of large case series studies indicates that ETS can be an effective treatment for intractable primary palmar hyperhidrosis. There is also evidence that ETS can be effective for hyperhidrosis in other sites, such as the axilla

and craniofacial regions, although reported success rates are somewhat lower than those reported for palmar sweating. Serious complications are rare, but can occur, and compensatory sweating is common, and may be severe. Based on the available data, a **HAYES Rating**™ of **B** has been assigned for endoscopic thoracic sympathectomy as a treatment for patients with severe primary palmar hyperhidrosis who have failed appropriate nonsurgical therapies, and for whom the condition causes significant social, psychological, or employment-related disability. A **Rating** of **C** has been assigned for ETS as a treatment for severe primary axillary or craniofacial hyperhidrosis. This **Rating** reflects the somewhat lower success rate and higher rate of recurrence of symptoms in patients with hyperhidrosis in these sites, compared with palmar hyperhidrosis. A **Rating** of **D** has been assigned for ETS as a treatment for patients with plantar hyperhidrosis as the only indication. This **Rating** reflects the paucity of evidence regarding the efficacy of ETS for hyperhidrosis at this site.

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Background Information:

Normal physiological sweating occurs over the entire skin surface and is essential for thermoregulation; sweat production increases and aids in evaporative cooling of the skin during times that the body is required to lose heat. Sweat is produced by two types of sweat glands, eccrine and apocrine. The eccrine sweat glands, found throughout the skin, are highly concentrated in the palms and soles of the feet, and secrete a clear odorless salty fluid directly onto the surface of the skin. Sweating is under the control of both circulating catecholamines and sympathetic innervation, and both eccrine and apocrine glands are stimulated by cholinergic as well as alpha- and beta-adrenergic agonists. Generally, spinal cord segments T2-T4 supply sweat glands on the head and neck, T2-T8 supply glands of the upper limbs, T6-T10 supply the trunk, and T11-L2 supply the lower extremities.[1-4]

Hyperhidrosis is a pathologic condition characterized by abnormal excessive sweating. Focal hyperhidrosis can occur at various areas of the body including the palmar, plantar, axillary, facial, and inguinal regions, and can be accompanied by facial blushing. Primary hyperhidrosis is characterized by increased sympathetic activity at the upper thoracic (dorsal) ganglia T2 and T3 with no apparent underlying cause. Hyperhidrosis can also occur secondary to a variety of neurological or systemic diseases such as thyrotoxicosis or pheochromocytoma and can occur as a side effect of sympathomimetic drugs.[2,5,6]

Approximately 1% of the world's population is affected by primary hyperhidrosis, with a high prevalence in some Asian populations and in Israel. Symptoms of hyperhidrosis often appear during adolescence, and if untreated, usually persist throughout adult life. The excessive sweating can ruin clothing, produce considerable emotional distress, and lead to significant social and occupational disability. Hyperhidrosis can also lead to a vulnerability to a variety of cutaneous diseases, such as dermatitis, fungal conditions, and secondary microbial infections.[2,3,5-9]

Conservative treatment for hyperhidrosis often begins with the use of topical aluminum chloride, however, aluminum salts can cause skin irritation and intense itching. Other noninvasive treatments include iontopheresis, which requires repeated treatments of the affected region, and oral anticholinergics and beta-blockers, which have numerous side effects, such as nausea, dizziness, blurred vision, and dry mouth. Recently, a number of studies have demonstrated that injections of botulinum toxin in the affected region can reduce excessive sweating, likely through blocking presynaptic release of acetylcholine. However, the effect is temporary, and repeated injections are necessary.[1,4,9-11]

Although many patients with mild cases of primary hyperhidrosis respond to medical therapies, some patients with more severe forms remain refractory and may require surgical intervention. The goal of surgery for hyperhidrosis is to disrupt the sympathetic supply to sweat glands by destroying relevant ganglia in the upper thoracic sympathetic chain. Upper thoracic sympathectomy is designed to reduce palmar, axillary, and, more rarely, craniofacial sweating, but is not intended to treat plantar hyperhidrosis. In the

past, upper thoracic sympathectomy involved a large incision in the chest and resection of the lower portion of the T1 ganglion down to the 4th and 5th ganglia. However, at the present time, a more limited sympathectomy is performed endoscopically; this procedure involves resection or ablation of the T2 ganglion for palmar hyperhidrosis, and resection of the 3rd and 4th ganglia for patients with axillary hyperhidrosis. Recently, clips placed on the sympathetic chain have been used as an alternative to resection or thermal ablation of the ganglia.[12-14] Endoscopic thoracic sympathectomy (ETS) is usually performed under general anesthesia on an outpatient basis, although in some cases a short hospital stay is required.

Regulatory Status of the Technology:

Food and Drug Administration (FDA)

Endoscopic thoracic sympathectomy, as a procedure, is not regulated by the FDA. However, the equipment and instruments used for ETS are regulated by the FDA. There are a large number of endoscopes, light sources, imaging devices, and radiofrequency probes, which are used for ETS and that have been approved by the FDA, although not necessarily for this specific application.[15]

Centers for Medicare & Medicaid Services (CMS), formerly Health Care Financing Administration (HCFA)

There is no national policy regarding Medicare coverage of ETS as a treatment for hyperhidrosis.[16]

Clinical Research Studies:

Search Strategy: Evidence evaluated in this report was identified through a search of MEDLINE, EMBASE, and Current Contents databases spanning the years 1985 to December 2002. Search terms included *hyperhidrosis* combined with *sympathectomy*, and results were limited to those studies that utilized endoscopic techniques. All studies using comparison groups were selected for review, as well as case series studies with at least 100 patients.

Literature Review: There were a number of studies evaluating ETS for treatment of primary hyperhidrosis in the literature; almost all of the studies were case series, some very large and a few with long-term follow-up on at least some of the patients. Only one study was randomized; this was a small study that compared operative parameters and short-term results in patients randomized to either open supraclavicular sympathectomy or thoracoscopic sympathectomy. Many of the studies were from Taiwan, South Korea, and Israel, reflecting the relatively high frequency of hyperhidrosis in these countries. Although none of the studies were controlled, most involved patients who had failed previous medical therapies. Outcome measures were largely subjective, primarily involving assessment of efficacy and patient satisfaction using a questionnaire sent to the patient. Follow-up times varied, ranging from 1 month to several years, with one study[17] providing follow-up data for 8 years on some patients, and another providing a mean of over 14 years of follow-up.[18]

The one small randomized study that compared postoperative results following open or endoscopic sympathectomy found that operative times were shorter, hospital days less, and patient satisfaction higher after the open procedure compared with the endoscopic

procedure.[19] However, this was an early study, and it is likely that the endoscopic technique used at that time was not as highly refined as those currently in use.

One large case series[17] involved a technique of stereotactic percutaneous thermocoagulation of the upper thoracic sympathetic ganglia, while the other studies used various methods of ablation, resection, or clipping under direct endoscopic or video guidance. The results of these studies indicate that minimally invasive sympathectomy, performed either endoscopically or percutaneously, can provide relief from palmar or axillary hyperhidrosis in the majority of patients, with some efficacy for craniofacial and plantar hyperhidrosis. Reported success rates ranged from 67% to 100% for treatment of palmar hyperhidrosis, which was the most common site being treated.

Success rates for axillary hyperhidrosis were somewhat lower than for palmar hyperhidrosis, ranging from 33% to 75%. Three studies included patients with craniofacial hyperhidrosis, who reported 95% to 100% satisfaction with the outcome.[17,20,21] One study also reported a decrease in plantar sweating in 92% of patients, although plantar hyperhidrosis was not the primary indication for surgery.[17] Lin et al. (2002) examined recurrence of symptoms after sympathectomy, reporting a 5-year recurrence rate of 13% for palmar hyperhidrosis, and 17% for axillary hyperhidrosis.[14]

Evidence from the studies evaluating the safety and efficacy of ETS for treatment of primary hyperhidrosis is summarized in the Table.

Table.–Studies Assessing the Safety and Efficacy of Endoscopic Thoracic Sympathectomy for Hyperhidrosis

Key: ETS, endoscopic thoracic sympathectomy; f/u, follow-up; grp(s), group(s); HH, hyperhidrosis; LOS, length of stay; NR, not reported; NS, difference not significant; PST, palmar skin temperature; pt(s), patient(s); T, thoracic; tx, treatment

Authors/ Study Design	Study Population	Treatment/ Outcome Measures	Results	Comments/ Conclusions
Chen et al. (1994)[22] Chang Gung Medical College, Kaohsiung, Taiwan Case series *F/u:* 2-12 mos *Time frame:* All surgeries were performed during a 2-yr period	n=180 pts (116 females, 64 males; mean age, 22 yr) w/ palmar HH *Inclusion criteria:* Incapacitating HH in the upper extremities *Exclusion criteria:* NR	All pts underwent ETS - involved electrocoagulation of T2 w/ monitoring of PST; T3 cauterized if no PST response to T2 ablation *Outcome measures:* Efficacy, as evaluated by pt-reported questionnaire	Immediately postop, 80% of pts were much improved, 15% moderately improved, 3% slightly improved, and 2% showed no change. At 2.5 mos f/u, 79% of pts were much improved, 13% moderately improved, 6% slightly improved, and 2% showed no improvement. Mean operating time, 30 min; all pts discharged in <24 hrs. 70% of pts reported compensatory HH. *Complications:* Subcutaneous emphysema (3); numbness of arms (3)	Results suggest ETS can be an effective tx for palmar HH, although compensatory HH common. *Limitations:* Subjective outcome measures; no long-term f/u.
Hashmonai et al. (1994)[19] Israel Institute of Technology, Haifa, Israel Prospective randomized trial comparing open w/ thoracoscopic sympathectomy procedures *F/u:* 1 mo *Time frame:* Jan 1992-Mar 1993	n=24 pts w/ palmar HH randomized to open supraclavicular sympathectomy (n=12; 7 men, 5 women; mean age, 25 yr) or thoracoscopic sympathectomy (n=12; 9 men, 3 women; mean age, 22) *Inclusion criteria:* Palmar HH *Exclusion criteria:* NR	All pts had electrocoagulation of T2, T3, and usually T4 *Outcome measures:* Surgical and operative time; length of inpt stay; efficacy and pt satisfaction, as evaluated by pt questionnaire	Operative data (open sympathectomy; ETS): Mean anesthesia time (min) – 113; 157 (*P*=0.003) Mean operating time (min) – 77; 88 (NS) Mean hospital days – 1.58; 2.17 (*P*=0.005) Both pt grps had 100% dry limbs postoperatively; mean pt satisfaction on 1-10 scale – 9.58 open sympathectomy; 7.33 ETS (*P*=0.005). *Complications:* Neurological problems (3); temporary Horner's syndrome (2); wound abscess (1); chest pain >1 wk (1); complications for ETS included chest pain >1 wk (8), bleeding (1), fever >37.5°C >3 days (1), neurological problems (1)	Open sympathectomy is associated w/ shorter anesthesia time, similar convalescence, and greater pt satisfaction than ETS. *Limitations:* Very small sample size; endoscopic technique may not be equivalent to current endoscopic techniques; lack of long-term f/u data.
Herbst et al. (1994)[18] University of Vienna, Austria Retrospective case series *F/u:* Mean 14.6 yrs (range 9 mos-27 yrs) *Time frame:* 1965-1992	n=270 pts (150 men, 120 women; mean age, 31 yr) w/ palmar and/or axillary HH *Inclusion criteria:* Palmar and axillary HH *Exclusion criteria:* NR	All pts had thorascopic electrocoagulation of T1/2 to T4 *Outcome measures:* Efficacy and pt satisfaction as assessed by pt-reported questionnaire Questionnaire was sent to 323 pts; response rate was 83.5%	265 pts (98.1%) who responded to questionnaire reported warm, dry hands w/in 4 days postop. Of 39 w/ only axillary HH, 37 (94.8%) experienced symptom relief w/in 4 days postop (NS). At f/u, 180 responding pts (66.7%) were satisfied, 72 (26.7%) partially satisfied, 18 (6.7%) unsatisfied. For the 39 pts w/ only axillary HH, 13 (33.3%) were satisfied, 18 (46.2%) partially satisfied, 8 (20.5%) unsatisfied. 67.4% pts reported compensatory HH. *Complications:* Recurrence in 4 pts, respiratory pain (14.4%), local pain (12.3%), Horner's syndrome (2.5%), pneumothorax (2.3%), ptosis (1.4%), and pleural effusion (0.2%).	Results suggest ETS can be effective for tx of palmar HH, may be less effective for axillary HH; compensatory sweating common. *Limitations:* Retrospective study; uncontrolled; subjective outcome measures; no f/u on 16% of pts in original series of 323 pts.

Authors/ Study Design	Study Population	Treatment/ Outcome Measures	Results	Comments/ Conclusions
Shachor et al. (1994)[23] University of Tel Aviv, Israel Case series *F/u:* 60 pts followed for 12 mos *Time frame:* Jan 1990-Dec 1992	n=150 pts (89 females, 61 males; age, 13-55 yr) w/ palmar HH *Inclusion criteria:* Primary palmar HH *Exclusion criteria:* NR	All pts had thorascopic electrocoagulation of T2-T4 *Outcome measures:* Efficacy and pt satisfaction, as evaluated by pt-reported severity of symptoms	98% pts considered outcome successful. Compensatory sweating occurred in 30/60 (50%) pts evaluable at 12-mo f/u; 3/60 (5%) pts had recurrence. *Complications:* Subcutaneous emphysema (8), pneumothorax (7), hemothorax (3), and Horner's syndrome (2). Pleural adhesions prevented 2 procedures, excessive adipose tissue prevented 1 procedure.	Results suggest ETS is effective for tx of palmar HH; compensatory sweating occurred in 50% of pts. *Limitations:* Uncontrolled study; subjective outcome measures; 12-mo f/u available for only 40% of pts.
Drott et al. (1995)[24] Borås Hospital, Borås, Sweden Case series *F/u:* Median 31 mos *Time frame:* All operations were performed after 1987	n=850 pts (39% males, 61% females; mean age, 27 yr) w/ palmar HH *Inclusion criteria:* Disabling HH *Exclusion criteria:* NR	All pts had thorascopic sympathectomy at the level of T2 and T3 for palmar HH, T2-T4 for axillary HH, T1-T4 for facial HH *Outcome measures:* Efficacy and pt satisfaction, as evaluated by pt-reported questionnaire	Immediately postop, 98% of pts had successful result, 2% failed to stop sweating. At f/u, 98% were satisfied with results; 17 developed recurrent symptoms, reoperation successful in 15. Compensatory sweating in 55%, gustatory sweating in 36%. *Complications:* Hemothorax (5), pneumothorax (4), permanent Horner's syndrome (2), transient Horner's syndrome (1). 39% pts required mild analgesics for a median of 3.4 days postop.	Results suggest ETS is effective for tx of palmar HH; compensatory or gustatory sweating common. *Limitations:* Uncontrolled study; subjective outcome measures; unclear what percentage of total was available for f/u.
Cohen et al. (1998)[25] Ben-Gurion University of the Negev, Beer-Sheva, Israel Retrospective case series *F/u:* 3 mos-4 yrs *Time frame:* Jan 1993-Jan 1997	n=223 pts (135 female, 88 male; mean age, 15 yr) w/ palmar and/or axillary HH *Inclusion criteria:* Palmar and axillary HH *Exclusion criteria:* NR	Pts had ETS at the level of T2 and T3 for palmar HH and at the level of T4 in cases of severe axillary HH *Outcome measures:* Efficacy and pt satisfaction, as evaluated by pt-reported questionnaire	98.2% pts were completely satisfied and had temporary and permanent relief from HH. 44.4% pts had compensatory sweating. *Complications:* Pneumothorax (2%)	Results suggest ETS is effective in treating palmar and axillary HH. *Limitations:* Retrospective study; uncontrolled; subjective outcome measures; variable length of f/u.
Lin and Fang (1999)[26] * Chung Shan Medical University, Taichung, Taiwan Retrospective case series *F/u:* Mean 27.8 mos (range 4-48) *Time frame:* July 1994-May 1998	n=1360 pts (816 female, 544 male; mean age, 23 yr, range 5-60) w/ palmar HH *Inclusion criteria:* Palmar HH and failure of nonoperative tx *Exclusion criteria:* NR	2715 ETS ablation procedures of the T2 ganglion were performed *Outcome measures:* Efficacy, as evaluated by pt-reported questionnaire	95% of pts reported highly satisfactory results. 84% of pts reported compensatory sweating of the trunk and lower limbs. *Complications:* Residual pneumothorax in 6 pts (0.44%)	Results suggest ETS is safe and effective for tx of palmar HH; compensatory sweating common. *Limitations:* Retrospective study; uncontrolled; subjective outcome measures; variable range of f/u.

Authors/ Study Design	Study Population	Treatment/ Outcome Measures	Results	Comments/ Conclusions
Lee et al. (2000)[27] Yonsei University College of Medicine, Seoul, Korea Retrospective case series *F/u:* Mean 4 mos *Time frame:* June 1997-Oct 1997	n=94 pts (52 female, 42 male; mean age, 23 yr, range 14-63) w/ palmar and/or axillary HH *Inclusion criteria:* HH and failure of nonoperative tx *Exclusion criteria:* NR	All pts underwent bilateral ETS using a biportal method and 2-mm endoscope, bisecting T2 for palmar HH, and bisecting T3 and T4 for axillary HH *Outcome measures:* Efficacy evaluated by clinical exam and pt-reported questionnaire	Satisfaction was noted by 95.8% of pts reporting satisfactory results. Compensatory sweating occurred in 67 (71%) pts. Most cases were treated on an outpt basis, mean inpt hospital stay was 1 day (range 0-5). *Complications:* Residual pneumothorax (5), Horner's syndrome (1)	Results suggest ETS using the 2-mm needlescope is effective in the tx of palmar and axillary HH. *Limitations:* Retrospective study; uncontrolled; subjective outcome measures; short duration of f/u.
Reisfeld et al. (2000)[20] Center for Hyperhidrosis, Los Angeles, CA Prospective case series *F/u:* 1 yr *Time frame:* Oct 1996-Feb 1999	n=650 pts (338 male, 312 female) w/ palmar (n=585) or craniofacial (n=65) HH *Inclusion criteria:* Disabling HH *Exclusion criteria:* NR w/ palmar or craniofacial HH	All pts underwent ETS – 648 pts underwent bilateral ablation of T2 ganglion; 2 pts underwent unilateral ablation *Outcome measures:* Operative time; complications; efficacy, as evaluated by pt-reported questionnaire	Palmar HH was resolved in 584/585 (>99%) pts. Craniofacial HH was resolved in 62/65 (95%) pts. Surgical time <1 hr; discharge w/in 2 hrs after surgery. 321 pts returned questionnaire after 1 yr: Compensatory sweating in 83% of reporting pts; considered mild or moderate in 67% of these pts; gustatory sweating in 30% of reporting pts. *Complications:* No major adverse events; hemothorax (7 pts); pneumothorax (1 pt)	Results suggest that ETS can be effective in majority of pts w/ palmar HH, can also be effective for facial HH; compensatory sweating common. *Limitations:* Case series study; uncontrolled; subjective outcome measures.
Vanaclocha et al. (2000)[28] University of Navarra, Pamplona, Spain Retrospective case series *F/u:* Mean 12 mos (range 2-56) *Time frame:* 1995-1999	n=100 pts (46 female, 54 male; mean age, 23 yr, range 12-54) w/ palmar HH *Inclusion criteria:* Palmar HH w/ no underlying cause, prior unsuccessful tx *Exclusion criteria:* NR	All pts underwent bilateral ETS of T2, T3, and T4 using a uniportal method and 6-mm endoscope *Outcome measures:* Total operative time, clinical and radiographic exam, pt satisfaction as evaluated by pt-reported questionnaire	Sympathectomy was accomplished on all pts w/in 30 min. 96% had an uneventful postop course. 5 pts reported recurrence of HH during f/u, and were successfully re-operated. *Complications:* 4 pts had residual hemothorax requiring drainage	Results suggest uniportal endoscopy is a safe and effective method for performing ETS. *Limitations:* Retrospective study; uncontrolled; some outcome measures subjective; relatively short f/u on some pts.
Gossot et al. (2001)[29] Institut Mutualiste Montsouris, Paris, France Case series *F/u:* 1 mo *Time frame:* 1995-1999	n=467 consecutive pts (303 female, 164 male; mean age, 31 yr, range 15-59) w/ palmar HH *Inclusion criteria:* Intractable palmar HH *Exclusion criteria:* NR	All pts underwent ETS; 267 pts underwent surgery as 1-stage operation; 182 pts had 2-stage operation *Outcome measures:* Hospital LOS; early complication rate	Mean hospital LOS: 1.1 day for pts w/ 1-stage operation; 2.3 days for pts w/ 2-stage operation *Complications:* 3 major complications (torn right subclavian artery (1), chylothorax (2)); bleeding during dissection of sympathetic trunk (25); pneumothorax (12); unilateral partial Horner's syndrome (4); mild pleural effusion (1)	Findings suggest that significant complications can occur during and after ETS, although incidence is relatively low. *Limitations:* Uncontrolled study; no information regarding skill and experience of surgeons; no long-term f/u.

Authors/ Study Design	Study Population	Treatment/ Outcome Measures	Results	Comments/ Conclusions
Han et al. (2002)[21] St. Joseph's Hospital and Medical Center, Phoenix, AZ Case series *F/u:* Mean 14 mos (range 2-36) *Time frame:* May 1996-Sept 2000	n=103 pts (72 female, 31 male; mean age, 28 yr, range 14-52) w/ HH *Inclusion criteria:* Craniofacial, palmar or axillary HH *Exclusion criteria:* NR	All pts underwent ETS: For craniofacial HH, ETS was performed at the level of T2 and T3; for axillary HH, ETS was performed at the level of T3 and T4 *Outcome measures:* Efficacy and pt satisfaction, as evaluated by pt-reported symptom severity	Complete relief of symptoms: 100% of pts w/ palmar HH 100% of pts w/ craniofacial HH 75% of pts w/ axillary HH 57% of pts had compensatory HH. *Complications:* Residual pneumothorax (2); unilateral Horner's syndrome (5)	Results suggest ETS is effective for tx of HH, particularly for palmar and craniofacial HH; compensatory HH common. *Limitations:* Uncontrolled; subjective outcome measures; relatively short f/u.
Chuang and Liu (2002)[17] Foo-Yin Technological University Hospital, Ping-Tung Hsien, Taiwan Case series *F/u:* 1-8 yrs *Time frame:* Nov 1986-May 1998	n=1688 pts w/ palmar HH and 54 pts w/ craniofacial HH *Inclusion criteria:* Craniofacial or palmar HH *Exclusion criteria:* NR	All pts underwent sympathectomy under local anesthesia alone; percutaneous stereotactic thermocoagulation technique used; T2 and T3 or T2 ganglionectomy performed *Outcome measure:* Efficacy, as reported by pt	Complete relief of HH in 99.5% sides immediately after surgery. No difference in results between T2 and T3 ganglionectomy and T2 alone. HH recurred w/in 2-59 mos in 268 procedures; all pts successfully retreated. Decreased plantar sweating reported in 92% of pts. *Complications*: Pneumothorax (7); partial Horner's syndrome (5)	Results suggest that percutaneous stereotactic thermocoagulation technique can eliminate palmar and craniofacial HH, and can also be effective for plantar HH in most pts; complications were rare. *Limitations:* Uncontrolled, subjective outcome measures; variable length of f/u.
Lin et al. (2002)[14] * Chung Shan Medical University, Taichung, Taiwan Case series *F/u:* Mean 52 mos (range 6-89) *Time frame:* Apr 1993-Mar 2000	n=1520 pts w/ palmar HH and 480 pts w/ axillary HH (1212 females, 788 males; mean age 23 yr, range 9-60) *Inclusion criteria:* Axillary or palmar HH *Exclusion criteria:* NR	1992 pts underwent ETS; T2 level for palmar HH; T3-T4 for axillary HH *Outcome measures:* Efficacy, as reported by pt questionnaire; complications	Recurrence rates for HH (palmar; axillary): 1-yr: 0%; 4.1% 2-yr: 0.1%; 8.2% 3-yr: 0.5%; 10.4% 4-yr: 0.6%; 14.1% 5-yr: 1.3%; 16.7% 86% of pts had compensatory sweating, w/ most severe sweating in pts who underwent T3-T4 sympathectomy. *Complications*: Pneumothorax (10); segmental atelectasis (7); hemothorax (2); mild wound infections (2)	Results suggest that ETS can eliminate palmar and axillary HH in majority of pts, w/ low recurrence rate, especially for palmar HH; compensatory sweating common, particularly after T3-T4 sympathectomy. *Limitations:* Uncontrolled, subjective outcome measures; variable length of f/u.

* Patient populations may overlap.

Patient Selection Criteria

Definitive patient selection criteria for ETS as a treatment for primary hyperhidrosis have not been established. However, there is sufficient evidence from large case series studies, some with long follow-up, to support the use of ETS for patients with primary palmar hyperhidrosis that is severe enough to cause social, psychological, or work-related disability, and that has been unresponsive to appropriate nonsurgical therapies.

Contraindications for ETS include pleural adhesions, which can make accurate identification and dissection of the sympathetic ganglia difficult, and any underlying condition that would pose a danger to the patient in the presence of pneumothorax.[29,30]

Complications/Safety Issues: Compensatory hyperhidrosis was the most common adverse effect of sympathectomy reported in the reviewed studies, with 44% to 86% of patients noting increased sweating elsewhere in the body after sympathectomy. This effect was generally more severe after T3-T4 sympathectomy than after T2 sympathectomy, and can be severe enough to interfere with lifestyle. Predicting which patients will experience compensatory hyperhidrosis is difficult, and severe compensatory sweating can occur even in patients who undergo a limited unilateral sympathectomy. Some studies also reported gustatory sweating as a sequela to sympathectomy, although less frequently than compensatory sweating.[29,31]

Other complications were relatively rare, with few serious adverse events reported. Pneumothorax occurred in up to 4.6% of patients in some studies, while Horner's syndrome, which is characterized by ipsilateral ptosis, miosis, and anhydrosis, was reported in between 0.2% and 2.5% of patients. Although this condition may resolve over a period of weeks to months, it can be permanent. Some authors suggest that Horner's syndrome can be avoided by only removing the T2 or the T2 and T3 segments of the sympathetic chain, although temporary Horner's syndrome can be induced by the heat of the diathermy probe transmitted to the lower part of the ganglion during endoscopic sympathectomy.[23,32]

Postoperative complications included pain, bleeding, pleural effusion, and subcutaneous emphysema, however, the incidence of these adverse events was low.

Approximately 10% of persons have an extraneural pathway that reaches the brachial plexus without passing the sympathetic trunk, known as the nerve of Kuntz. In those cases, autonomic stimulation will be transmitted even thought the sympathetic trunk is severed. Failure to destroy this nerve may lead to incomplete denervation.[18,24]

Thoracic sympathectomy does not appear to cause adverse physiological changes; only minimal and subclinical changes in pulmonary functioning have been reported.[33] Additionally, thoracoscopic sympathectomy was shown to have no influence on exercise capacity or ventilatory response to exercise, and had only minimal effect on cardiac response to exercise.[34]

Quality-of-life information

Only one small study addressed quality-of-life issues related to surgical outcome for hyperhidrosis treatment. Sayeed et al. (1998) used the Short Form-36 health assessment questionnaire to measure changes in quality of life after ETS. At a mean follow-up of 6.2 months, there was a significant improvement in social function and mental health among the16 patients in this study, despite a high incidence of compensatory sweating.[35]

Predictors of Surgical Outcome

Objective methods of measurement are rarely used in the diagnosis and measurement of treatment outcome of hyperhidrosis. Rather, the patients define what constitutes a disabling condition and a satisfactory surgical outcome.[24] However, when sympathectomy is performed, the monitoring of palmar skin temperature (PST) can confirm the accomplishment of a correct sympathectomy that yields a favorable

outcome. PST rises to 2°C when the T2 or T3 sympathetic nerve is ablated.[36] Kao et al. (1994) reported that all patients in their study who exhibited a PST over 3°C obtained satisfactory long-term results.[37] Lewis et al. (1998) found that sympathetic skin response (SSR) is not permanently abolished following sympathectomy but that the return of SSR does not correlate with symptom recurrence. The authors concluded that SSR measurement is a poor prognostic indicator of surgical outcome.[38]

Cost and Cost-effectiveness: No cost-effectiveness analyses regarding ETS were available in the published literature. Cost information was not available in the peer-reviewed literature, although information obtained from providers' Web sites indicates that the procedure costs between $5000 and $10,000 when performed on an outpatient basis.[39]

Ongoing and Future Research

Lin et al. (1998) argue for the use of endoscopic clips for hyperhidrosis treatment instead of sympathectomy or sympathicotomy. The clips provide the same therapeutic effect, that is, obstruction of sympathetic impulses, that removal provides. In their sample of 342 patients, 5 experienced intolerable compensatory sweating that was more distressing than the original sweaty hands. When the clips were removed, the compensatory sweating stopped and palmar sweating began in 3 patients; 1 patient responded with less compensatory sweating, and the last patient remained unchanged. The authors state that another advantage of the clip is that it avoids the possibility of Horner's syndrome since no transection of nerve fibers occurs.[12] Additional research exploring the advantages of endoscopic clips is warranted.

A search of the clinical and research trials databases identified one study involving botulinum toxin as a treatment for hyperhidrosis[40] and one study designed to characterize the genetics of primary hyperhidrosis and to investigate the regulation of sweating by the autonomic nervous system.[41] This latter study will recruit families with hyperhidrosis based on the identification of probands who have undergone thoracic sympathectomy. Detailed medical and family histories will be obtained, and a DNA sample will be collected from probands and family members. A segregation analysis will be performed to determine the mode of inheritance. This will be followed by the mapping and cloning of the hyperhidrosis gene in follow-on studies. This study may be useful for future development of more effective therapies.

Conclusions: Evidence from a number of large case series studies indicates that ETS can be an effective treatment for intractable primary palmar hyperhidrosis. There is also evidence that ETS can be effective for hyperhidrosis in other sites, such as the axilla and craniofacial regions, although reported success rates are somewhat lower than those reported for palmar sweating. Serious complications are rare, but can occur, and compensatory sweating is common, and may be severe. Based on the available data, a **HAYES Rating™** of **B** has been assigned for endoscopic thoracic sympathectomy as a treatment for patients with severe primary palmar hyperhidrosis who have failed appropriate nonsurgical therapies, and for whom the condition causes significant social, psychological, or employment-related disability. A **Rating** of **C** has been assigned for ETS as a treatment for severe primary axillary or craniofacial hyperhidrosis. This **Rating** reflects the somewhat lower success rate and higher rate of recurrence of

symptoms in patients with hyperhidrosis in these sites, compared with palmar hyperhidrosis. A **Rating** of **D** has been assigned for ETS as a treatment for patients with plantar hyperhidrosis as the only indication. This **Rating** reflects the paucity of evidence regarding the efficacy of ETS for hyperhidrosis at this site.

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Index Terms: Axillary hyperhidrosis, compensatory hyperhidrosis, craniofacial hyperhidrosis, endoscopy, essential hyperhidrosis, ETS, ganglia, ganglion, ganglionectomy, gustatory sweating, idiopathic hyperhidrosis, mini-endoscopic sympathectomy, palmar hyperhidrosis, phantom sweating, plantar hyperhidrosis, primary hyperhidrosis, secondary hyperhidrosis, stellectomy, supraclavicular thoracic sympathectomy, sympathetic arousal, sympathetic chain, sympathetic nervous system, sympathicolysis, sympathicotomy, thermoregulation, thoracoscopic, transaxillary thoracic sympathectomy, video endoscopic sympathectomy