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Evaluating the Role of Thoracoscopic Sympathectomy in Treatment of Palmar Hyperhidrosis in Children

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Abstract

The aim of our study was to evaluate the use of thoracoscopic sympathectomy in treatment of palmar hyperhidrosis in pediatric patients as regards methods, indications, contraindications, complications and follow up of patients undergoing thoracoscopic procedures. Twenty patients with palmar hyperhidrosis Grade 3 and 4 HDSS amenable for thoracoscopic sympathectomy were primarily managed. The study compromise 12 males and 8 females; the mean age at intervention was 10 (range 6 to14) years. All were evaluated preoperatively with detailed history, full physical examination and the required investigations to confirm the diagnosis and to assess the fitness for surgery. Consent was then taken after discussing everything with the parents. All cases were intubated with double lung ventilation; no single-lung ventilation was used due to anesthetic difficulties. In all cases the procedure was completed thoracoscopically, and none of our patients required conversion to open surgery. Patients were evaluated postoperatively and followed up for at least 3 months postoperatively. Careful patient selection is essential to minimize the morbidity of thoracoscopic procedures. Thoracoscopic sympathectomy is a straight forward procedure, resection of the sympathetic chain rather than cauterization helps to decrease the incidence of recurrence, yet it might be associated with longer operative time and higher incidence of excessive dryness, which is usually well tolerated by the patients. One patient required redo surgery; no patients had a significant morbidity related to the thoracoscopic procedure and no single mortality. Thoracoscopic sympathectomy as performed in our institution offers comparable results and complications as previously published trials, but due to single-lumen ventilation the intraoperative management is a little bit prolonged. Therefore, this technique offers an interesting option for the treatment of patients with palmar and axillary hyperhidrosis. In the treatment of sympathetically mediated disorders, minimally invasive techniques for thoracoscopic sympathectomy have equivalent outcomes to those reported previously for open surgical techniques; however, the associated morbidity rate and the period of hospital stay are substantially reduced when utilizing these newer techniques. Our experience suggests that video-assisted thoracic bilateral thoracoscopic sympathectomy constitutes a valid and feasible intervention for the definitive treatment of palmar and axillary hyperhidrosis. However, the impact of thoracoscopic sympathectomy on the quality of patient life is still very difficult to assess, as such assessment involves various variables whether subjective or objective. Consequently, a protocol for case selection and different objective and subjective criteria for evaluation of outcome need to be carefully postulated. Taken together, the results obtained lead to support to the idea that the surgical technique of bilateral upper thoracic sympathectomy offers a favorable treatment for primary hyperhidrosis. This is exemplified by the high level of patient satisfaction, the very low morbidity rate, and the acceptable levels of postoperative comfort despite the notable incidence of compensatory hyperhidrosis.

Keywords: Sympathetic chain; Sweating; Thoracoscopy; Palmar hyperhidrosis

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Introduction

Primary or essential hyperhidrosis is a disorder characterized by excessive sweating in disproportion to that required for thermoregulation and dissipation of body heat. In most cases this excessive sweating is aggravated by emotional factors and also by heat. Hyperhidrosis presents preferential sites such as head and face, palms, soles and axillae, in addition to their various associations. However, the severe clinical characteristic of hyperhidrosis is the intense discomfort it causes to the patient. This discomfort can be seen in a great number of routine activities, leading to significant unease, embarrassment and shame, and severely compromising the affective, professional and social life of those affected. The etiology of this dysfunction is not completely known yet, but it is certain that there is excessive sympathetic stimulation by the sudomotor center [1].

Copious palmar sweating causes difficulty in social contact, writing, manual activities, and handling objects, among others. Sweaty feet, besides the discomfort they produce, render the use of sandals or even walking barefoot difficult. Axillary hyperhidrosis dampens and stains clothes in addition to embarrassing their wearers, who usually then use only black or white clothes. Craniofacial hyperhidrosis intensely embarrasses those who present it, by drawing attention to them and at the same time making them feel insecure, afraid and lacking in confidence. There is no doubt that there is clinical predominance of varying intensities of embarrassment, isolation, insecurity and difficulties in the sufferers' social, professional and affective lives. In a significant number of cases this insecurity is aggravated by the little importance given to the patient's complaint, both by relatives and even by the attending physicians, failure in the diagnosis and often a succession of previously proposed ineffective measures [1].

A standard definition of excessive sweating has not yet been established. Quantification of sweat production in studies has ranged from normal being defined as less than 1 mL/m2/min to the production of less than 100 mg of sweat in one axilla within 5 min, or less than 50 mg within 1 min. The fundamental criticism of these measurement parameters is the fact that they fail to take into account surface area. As a consequence, smaller people may end up falling below this quantitative definition, despite excessive and debilitating sweating. For practical purposes, any degree of sweating that interferes with activities of daily living can be viewed as hyperhidrosis [2].

Hyperhidrosis is divided into primary or idiopathic hyperhidrosis and secondary due to a variety of causes. This classification is further categorized as generalized or focal with respect to its clinical presentation. Primary or idiopathic hyperhidrosis is usually focal and limited to the axillae, palms and soles, and face. Secondary hyperhidrosis can be focal or generalized, affecting the entire body. The focus of this study is on the diagnosis and management of hyperhidrosis, with a focus on primary focal idiopathic hyperhidrosis. With a reported prevalence of 2.8% of the population, and associated significant psychosocial morbidity, it is imperative that physicians recognize this disease entity and understand the various treatment modalities that are available. Treatment strategies for hyperhidrosis include topical, oral, surgical, and nonsurgical treatments. These treatment modalities differ with respect to their therapeutic efficacy, duration of effect, side effects, as well as cost of therapy [2].

For many years it has been known that cervicothoracic sympathectomy can eliminate palmar hyperhidrosis symptoms. The presence of serious complications after conventional surgery, especially Horner's syndrome caused by stellate ganglion injury, has led this procedure to be little used in the treatment of hyperhidrosis [3].

In the 1950s, Edhard Kux used direct thoracoscopy to successfully perform thoracoscopic sympathectomy, with the potential ability to avoid such complications. However, this important advance did not have the expected impact probably because minimally invasive surgeries at that time were not popular, nor did they receive attention from the medical community. In the 1990s, the systematization of video-assisted thoracoscopy allowed thoracic sympathectomy to be indicated and used with significant benefit to patients. Thoracoscopic sympathectomy is indicated in different situations, notably hyperhidrosis, reflex sympathetic dystrophy and ischemic upper limb syndromes [3].

Good results using thoracoscopic sympathectomy have been presented by some groups, although hyperhidrosis represented a small proportion of the cases. Upon reviewing the literature, the extremely small number of hyperhidrosis cases undergoing operation becomes evident. We believe that this is probably due to insufficient knowledge of the disease among our colleagues (may be due to the huge clinical interface involved) as well as among patients themselves. From the outset, the enormous satisfaction of hyperhidrosis patients undergoing operation has been noteworthy. There has been a great flow of patients, many of whom without previous diagnosis or attributing their condition to "anxiety", "this is my nature", "weakness" or even "dirtiness" (usually a depreciative situation), as well as the characteristic nuisance in everyday life. Such unexpected incidence seems to show that this disorder, which is so frequently without diagnosis, may present higher prevalence than we had supposed. At the same time, this increase in experience has fostered several modifications and simplified the surgical technique, which has become quicker, safer and cheaper [1].

The aim of the present study is to assess the feasibility, advantages, disadvantages and outcomes of thoracoscopic sympathectomy among children presenting severe and disabling hyperhidrosis who were submitted to video-assisted thoracic sympathectomy.

Patients and Methods

A study on endoscopic thoracic sympathectomies for palmar hyperhidrosis was undertaken based on case history, a pre- and postoperative questionnaire survey and perioperative data.

The sample comprised 20 patients. Excessive sweating of the palms was experienced by all, and excessive sweating of the soles was experienced by 18 (90%) patients. All of these patients complained of hyperhidrosis causing considerable social embarrassment and interfered with the performance of everyday tasks. The most consistent complaints were embarrassment on shaking hands and difficulties in writing and drawing. Twelve patients (60%) were males and eight patients (40%) were females; the mean age at intervention was 10 (range, 6 to 14) years.

Patients underwent thoracoscopic sympathectomy. Diagnosis was based on clinical feature. Written, informed consent was obtained from all patients. All data, including sex, age, medication, and complications, were obtained from clinical records. Clinical follow-up data were obtained by reviewing hospital records and direct communication with the patients or attending physicians. All patients answered a questionnaire concerning changes in sweating and quality of life (scale: improved, unchanged) as well as compensatory and gustatory sweating (present or no gustatory/compensatory sweating) and overall satisfaction with the results of the operation. Bilateral video-assisted thoracoscopic sympathectomies were performed in 8 cases, 2 cases in two stage procedures, and in 6 cases bilateral sympathectomy was done in single stage procedure. The mean follow-up period was 6 months, ranging from 3 to 12 months. None of the patients had undergone a previous hyperhidrosis operation. Patient satisfaction was classified into four grades: very satisfied, satisfied, fair, and unsatisfied. The reasons for dissatisfaction were also reviewed.

Inclusion criteria

Patients included in this study are those with primary palmar and/or axillary hyperhidrosis interfering with the quality of life, Grade 3 or 4 HDSS with failed medical treatment for at least 6 month.

Exclusion Criteria

- Age above 14 years.
- Patients with respiratory or haemodynamic compromise.
- Previous thoracotomy.
- Failed previous thoracoscopy, where failure means significant complication related to the thoracoscopic procedure.
- Patients with suspected cause of secondary hyperhidrosis e.g hyperthyroidism, pheochromocytoma, Hodgkin's disease or psychosis.

Preoperative evaluation

After detailed history and full physical examination, each patient underwent the proper investigations to confirm the diagnosis and assess the fitness for surgery. Consent will be taken after discussing with the parents the details of the procedure, expected benefits and possible intra- and postoperative complications.

These patients will be studied through following regimen:

A. Clinical history: In children scheduled for thoracoscopic procedures, the clinical scenario was of elective procedure. Personal history, including: age, sex, location and date of birth. Present history with onset of complains, past medical and surgical history. Family history with special attention to similar condition in any other relatives and positive consanguinity between parents.

B. Full clinical examination: The preoperative history and physical examination should be directed at identifying acute problems or underlying medical conditions as well as previously undiagnosed problems that can place the patient at an increased risk during the perioperative management.

*General examination:

- Weight.
- Body build, general appearance and overall activity.
- Blood pressure, pulse, temperature and respiratory rate.
- Chest examination.

*Special examination:

- Hand and sole examination with clinical assessment of severity of hyperhidrosis according to hyperhidrosis disease severity scoring system (HDSS) grade 1 to 4 for postoperative assessment of improvement of symptoms. Patients chosen in this study were either of moderate (Grade 3) or severe (Grade 4) cases.
- Proper examination of any possibly affected system.

C. Investigations:

*Laboratory tests:

- Preoperative laboratory evaluation depends on the clinical status of the patient more than the procedure itself.
- Full blood count, bleeding profile, urea and electrolytes are performed routinely.
- Liver and renal functions if needed.
- Arterial blood gases in selected patients.
- Additional preoperative evaluations such as pulmonary function testing or ECG are not routinely indicated, but rather obtained based on the patient medical history and associated underlying illness.

*Radiology:

- Plain chest X-ray postero-anterior (P.A.) view will generally be needed in most cases for preoperative assessment.
- Plain cervical spine X-ray to rule out cervical rib.
- Echocardiography for patients with history suggestive of cardiac problems.

D. Consent for surgery: Consent will be taken from the parents discussing with them the operative procedure and the possible intraoperative and postoperative complications, together with the need for postoperative ventilation and its possible hazards. Patients have to be thoroughly informed about success and complication rates as well as side effects of sympathetic surgery.

Operative technique

The goals of any approach should be a complete autonomic denervation of the hands without complications, no recurrence, minimal or no hospital stay, and the ability to perform single-stage bilateral sympathectomies, and include use of progressively smaller "needlescopic" ports to perform a sympathotomy with simple division of the sympathetic chain just above T2, and selective ramicotomy with division of the T2 to T3 sympathectomy with horizontal scoring of the bodies of ribs 2 and 3 to ablate any accessory fibers of Kuntz.

A. Premedication and anesthetic induction: Two venous accesses prior to the start of the procedure will mostly be inserted as the surgery is performed in the lateral decubitus position.

In patients with severe cardiac instability and where major haemodynamic fluctuations are expected, invasive arterial blood pressure monitoring will be used. Atropine will be administered as a vagolytic. Antiemetics and H2 antagonists will be administered in patients at risk for aspiration. Inhalational or intravenous induction followed by neuromuscular blocking drug will be used to facilitate endotracheal intubation. Intraoperative analgesic that will be generally used is Fentanyl. Under general anaesthesia, routine monitoring of ECG, oxygen saturation, end-tidal CO_2 and non-invasive blood pressure measurements are established.

B. Intraoperative anesthetic care: Thoracoscopy will be performed using general anesthesia either by the ordinary 2 lung ventilation or single lung ventilation using a regular single lumen endotracheal tubes (sized according to age). Prophylactic antibiotic dose was given routinely with the induction of anesthesia. Local anesthetic infiltration was given at the port sites to decrease postoperative pain.

C. Positioning: Patients underwent surgery while in a lateral decubitus position (i.e., leaning forward approximately 15 degrees beyond perpendicular) with the side on which surgery to be performed facing up; with 20o anti-Trendelenberg tilt of the table (Figure 1).

D- Sterilization and draping: Thorough sterilization of the operative field, using Povidone Iodine (Bethadine) was done. Then,

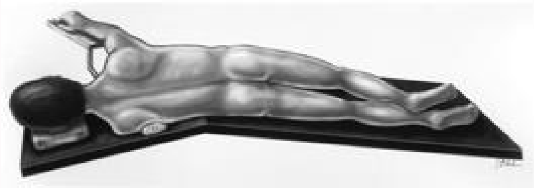

Figure 1: Artist's drawing depicting the lateral positioning of the patient (same as for a thoracotomy) undergoing right thoracoscopic sympathectomy [5].

Figure 2: Thoracoscopic instruments used in this study.

the whole body was covered, exposing the desired area.

E- Equipment and instruments: Tools are checked prior to surgery, the endoscopic tools included:

- Trocar: 5.5 mm diameter rigid trocar.
- Cannulas: 5.5 mm and 3 mm valved and non-valved cannulas.
- Telescope: 5 mm 45o telescope (Olympus AR-T10E).
- Camera: Olympus OTV-S7
- Colored video monitor, video output and recorder.
- Light source.
- Insufflator: (Martin).
- Thoracoscopic instruments: most of the instruments used were 20 cm to 30 cms in length, most of them were black coated to avoid light reflection and the shafts can rotate around their axes. These instruments included: Marylands, graspers, scissors, right angled forceps, monopolar and bipolar cautery and a 5-mm diameter suction/irrigation device, harmonic scalpel and Ligasure.
- Thoracoscopic instruments used in this study (Figure 2).

F. Room setup and position of the team: In this study, the whole team included four or five personnel; three or four were scrubbed, while the circulating nurse was not. In general, the surgeon and the assistant (camera man) were on the side facing the patient, while the scrub nurse and the second assistant (if needed) stood on the opposite side.

G. Ports and placement: Three ports are used. Port placement and location are important for good endoscopic visualization

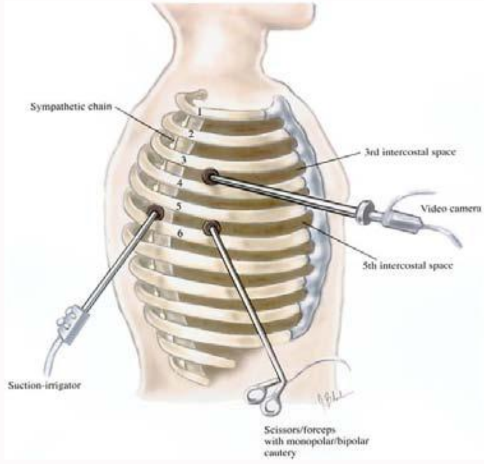

Figure 3: Artist's illustration showing the endoscopic port locations and instrument placement for sympathectomy procedure [5].

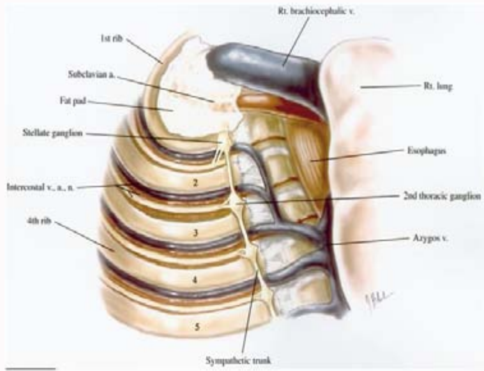

Figure 4: Artist's drawing of intrathoracic anatomy of right upper thorax demonstrating the location of sympathetic ganglia and chain. a. = artery; n. = nerve; v. = vein [5].

and manipulation of the instruments during the procedure. The endoscope is placed in one port, and the instruments are placed in the remaining ports (Figure 3).

H. Steps of the procedure: Adequate visualization was achieved by the routine use of low-flow (1 L/min), low-pressure (6 mmHg), CO_2 insufflation during the procedure, which kept the lung compressed. If visualization is not adequate, then the pressure and flow were gradually increased until adequate lung collapse was obtained. We did not increase the pressure more than 8 mmHg.

Exploration of the thoracic cavity is performed, and any adhesions of the lung and parietal pleura are coagulated and divided. The lung is manually retracted, which is facilitated by rotating the operating table and placing the patient in a reverse Trendelenburg position that allows the lung to fall away from the upper mediastinum.

Anatomical landmarks identified are the first through fourth ribs and the sympathetic chain beneath the pleura coursing over each rib head (Figure 4). To avoid hyperemia and obscured visualization, the pleura over the sympathetic chain should not be "palpated" with the endoscopic instruments. The extent of the removal of the sympathetic chain can be tailored to the individual patient. Resection of the T-2 sympathetic ganglion is the minimum requirement of the procedure. A more complete sympathetic denervation of the upper extremity and axilla involves excising the sympathetic chain from immediately

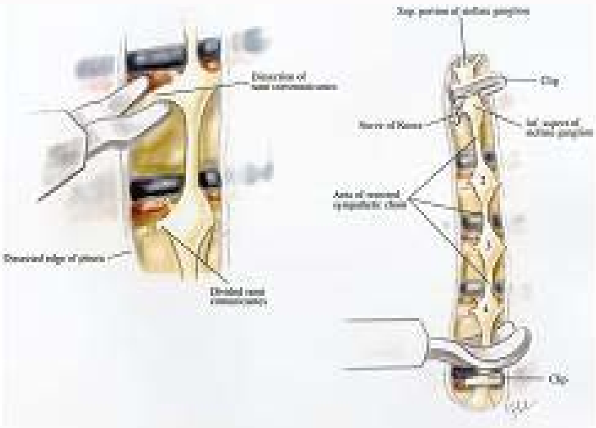

Figure 5: Illustration depicting division of rami communicantes at each level (left) and division of the sympathetic chain at the inferior aspect of the stellate ganglion and T-4 (right). Inf. = inferior; Sup. = superior [5].

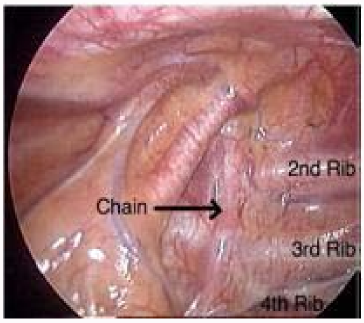

Figure 6: Identifying the chain.

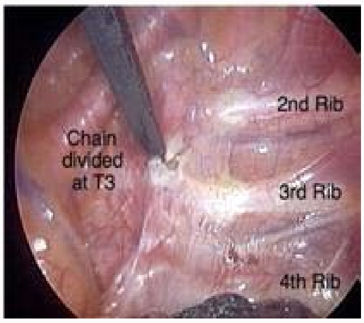

Figure 7: T3 sympathectomy.

below the stellate ganglion to T-4. The stellate ganglion is located within the fat pad that envelops the subclavian artery. The intercostal vessels course over the midportion of the vertebral body, and the azygos veins draining the intercostals veins should be avoided during the dissection of the sympathetic chain.

We use either hook cautery or harmonic scissors to open the pleura overlying the sympathetic chain. One important anatomic issue is the identification of the first rib and the upper border of the second rib. Avoidance of Horner's syndrome depends on preservation of the stellate ganglion at T1. If one limits dissection to below the upper border of the second rib, injury to the stellate ganglion can usually be avoided. The first rib is often difficult to visualize thoracoscopically. It is often covered by an area of bright yellow fat at its costovertebral junction, which serves as a useful landmark. The surgeon should thoracoscopically “palpate” the soft tissue above the apparent first rib to be sure there is no further cephalad rib. Once the first rib is localized, the pleura is opened and the second rib identified. No further dissection is carried out above the upper border of the second rib. This also decreases the chances for injury to the T1 outflow to the lower cord of the brachial plexus which crosses the first rib to join C8 and the lower cord of the plexus. The main sympathetic chain is then elevated from T2 to T3.

The dissection is begun by incising the pleura over the sympathetic chain by using curved scissors to gain exposure cephalad up to the stellate ganglion. The scissors are then used to dissect the sympathetic chain from its bed by dividing the rami communicantes at each level (Figure 5 left). The creation of a dissection plane immediately beneath the sympathetic chain avoids the underlying intercostal vessels, but occasionally, intercostal vessels course over the sympathetic chain and require either cauterization or clipping and dividing.

Resection of the sympathetic chain is extended cephalad to the inferior aspect of the stellate ganglion to achieve adequate sympathetic denervation of the lower trunk of the brachial plexus while avoiding injury to the stellate ganglion. The nerve of Kuntz is a large branch that extends caudally from the stellate ganglia (Figure 5 right) within the fat pad. The ramus arising laterally from the sympathetic chain is the Nerve of Kuntz, which is slightly larger than the other rami and must be interrupted to achieve adequate sympathetic denervation of the upper extremity. This also was transected by diathermy hook. To avoid injury that can result in Horner’s syndrome, the stellate ganglion should not be disturbed. The sympathetic chain is then excised and sent for histopathological examination to confirm tissue diagnosis. The dissection bed is irrigated and hemostasis is ensured. A small (No. 20–24 French) chest tube is inserted through the posterior axillary port, and the lung is reinflated by the anesthetist. The port incisions are closed in two layers, intramuscular and subcuticular skin suture. Finally, specimens were sent for histopathological assessment.

I. Recovery: At the completion of the procedure, the pneumothorax will be evacuated and the two lungs will be reinstituted. Several large volume breaths will be delivered to ensure reexpansion of the lung on the operative side. In most cases, residual neuromuscular blockade will be reversed, and the patient’s trachea will be extubated.

J. Postoperative care and pain management: Under water seal chest tube is placed in the posterior axillary port, and an immediate chest X-ray film is obtained to verify proper inflation of the lung. The chest tube is usually removed on the next day after chest X-ray.

Postoperative analgesia will be provided with long acting local anesthesia (Marcane). If there is no underlying qualitative or quantitative platelet issue, non steroidal anti inflammatory agents will be used to treat fever as well as provide adjunctive analgesia. Postoperative complications will be monitored especially air leak, bleeding as well as respiratory insufficiency and arrhythmias. The patients were mobilized early, and most patients were discharged on the 2^{nd} or 3^{rd} day postoperative.

Follow up

The first visit of the patient to the outpatient clinic is 7 days after discharge. The follow up at this time is focused on wound examination, patient reassurance and changing any medications if still needed. One month then three months clinical and radiological (if needed) follow up is then done for all the patients. Subsequent visits depend on the patient's condition. The follow up evaluation is based mainly on the following data:

Table 1: Hyperhidrosis disease severity score (HDSS) [4].

Grade 1	Sweating is never noticeable and never interferes with my daily activities
Grade 2	Sweating is tolerable but sometimes interferes with my daily activities
Grade 3	Sweating is barely tolerable and frequently interferes with my daily activities
Grade 4	Sweating is intolerable and always interferes with my daily activities

- Patient satisfaction and the effect on the quality of life.
- Medications needed: Cause, type and dose.
- Imaging: Chest x-ray done 1 month postoperatively to exclude partial lung collapse.
- Occurrence of complications during the follow up period.

Patients with hyperhidrosis were evaluated for the presence or absence of sweaty palms and surgery-related complications, and delayed-onset complications of compensatory hyperhidrosis or gustatory sweating were also determined. The incidence and severity of recurrent symptoms were evaluated, and patients were questioned as to their "overall satisfaction" and willingness to undergo a repeated procedure.

Results

Patients demographics included 12 males (60%) and 8 females (40%). The median age of the included patients (at time of surgery) was 10 years (range, 6-14). Ethnic origin was white in 100%. Twenty patients with excessive sweating in both upper limbs (palmar with or without axillary, plantar, or facial hyperhidrosis) interfering with the quality of their lives underwent video-assisted thoracoscopic sympathectomy in this study. 14 of them had palmar and axillary hyperhidrosis, while the other 6 had isolated palmar hyperhidrosis. All had associated plantar hyperhidrosis. Two of the patients had previous tonsillectomy. The others had no previous surgical procedures. Two of the patients had history of bronchial asthma. The others had no present history of other system affection. All had insignificant past medical history. Family history was irrelevant in all patients. On examination all were vitally stable, of average body built and had good overall activity.

All patients showed no abnormalities in their preoperative laboratory investigations. Plain cervical spine X-ray showed no cervical rib in any of them. After obtaining detailed consents and anesthetic consultations they were all scheduled for surgery (Table 1 and 2). Twelve patients underwent unilateral thoracoscopic sympathectomy to the right side being right handed persons. Eight patients underwent bilateral thoracoscopic sympathectomies, two patients on two staged procedures and six at the same session (Table 3). The average duration of postoperative stay ranged between 2 to 3 days (Table 4). After sympathectomy, 14 (70%) patients were completely free of sweating on the side of operation, 4 (20%) patients had partial relieve of symptoms (still have axillary sweating), and 2 (10%) patients were not improved (recurrent). Outcome is summarized in Table 5. The overall rate of postoperative complications were 10% (2/20 cases). One patient suffers from postoperative pneumothorax (5%, 1/20) due to kink and blockage of the chest tube, which resolve spontaneously after dealing with the chest tube, the other had hemothorax (5%, 1/20) that was controlled spontaneously by respiratory physiotherapy, and did not require blood transfusion. Isolated radiological subcutaneous emphysema was noticed in three patients and required no more than follow up. Pleural bleeding and atelectasis was noticed in none of our patients (Table 6). The most common postoperative side effect was compensatory sweating which was encountered in eight patients (40%). This phenomenon is also called reflex hyperhidrosis, and patients were always given information about it before surgery. It affects either the other innervated upper limb in patients who underwent unilateral sympathectomy or the trunk (abdominal or lumbar region) and feet in bilateral sympathectomy. This was seen in mild to moderate form and was tolerated by all patients.

Table 2: Clinic opatho logical characteristics.

	Value or median	% or range
Male	12	60%
Female	8	40%
Age (median/range) (years)	10	(6-14)
Duration of symptoms (yr)	3	(2-4)
Isolated palmar HH	6	30%
Combined palmar + axillary	14	70%

Table 3: Summary of 23 sympathectomy procedures in which uni- and bilateral approaches were used in 20 patients.

Type	No. of patients	No. of procedures
Unilateral	12	13
Right side	12	13
Left side	-	-
Bilateral	8	10
Staged	2	4
One stage	6	6

Table 4: Duration of postoperative stay following thoracoscopic sympathectomy.

Duration	Unilat. Sympathectomy (days)	Bilat. Sympathectomy (days)
Average	2	3
Range	3-Jan	4-Feb

Table 5: Outcome in 20 patients with hyperhidrosis undergoing thoracoscopic sympathectomy.

Disorder	Complete relief of symptoms	Partial relief of symptoms	Recurrent symptoms
Hyperidrosis	14 (70%)	4 (20%)	2 (10%)

Table 6: Early postoperative complications and results after operations for palmar hyperhidrosis in the 20 patients.

	No. of patients	% of total
Pneumothorax	1	5
Hemothorax	1	5
Port site bleeding	0	-
Horner's syndrome	0	-
Mortality	0	-
Immediate success rate	20	100

Pain at port site was encountered in 2 cases during the first month after intervention, mostly an invalid pain (sympathetic neuralgia) and improved during follow up period.

Approximately 70% of the patients reported a significant decrease in excessive palmar sweating (sweating only under intense heat). The remaining 30% either did not present a significant decrease in the palmar symptoms or were lost during follow up.

The immediate results were fairly good, but it seemed to worsen

Table 7: Long-term results of the 20 patients who underwent operations for palmar hyperhidrosis.

	No. of patients	% of total
Compensatory hyperhidrosis	8	40
Relapse	1	5
Hypohidrosis	1	5
Wound pain	2	10
Craniofacial hyperhidrosis (Fcial blushing)	1	5
Severe dryness of the hands	0	-
Unpleasant scar	0	-
Gustatory hyperhidrosis	0	-
Wound infection	0	-

with time. Relapses or persistence of less intense symptoms occurred in approximately 10% of the palmar hyperhidrosis cases.

In two patients (2/20, 10%) with hyperhidrosis who were operated on at the beginning of the series, partial recurrence of symptoms or hypohidrosis occurred. One patient (8 years old female) had an aberrant nerve on the right side, this was identified on redo for partial recurrence of symptoms and the nerve was resected. The second patient refused to undergo a redo procedure despite partial recurrence of symptoms.

Hypohidrosis of the denervated area was recorded in single case after 12 weeks of intervention, involving palmar and axillary hypohidrosis. It's to be considered as mild form of recurrence. In this patient the symptoms were controlled using medication and there was no need for reoperation.

Concedring facial blushing, postoperative craniofacial hyperhidrosis or facial blushing was observed in single case that underwent bilateral staged sympathectomy. It is to be considered as mild form of compensatory hyperhidrosis, or it was already present preoperative but was not noticed by the patient or exacerbated by sympathectomy (Table 7).

Discussion

Palmar hyperhidrosis is characterized primarily by excessive sweating in the palms and is aggravated by minor stresses. The cause is unknown and the incidence ranges from 0.15% to 1% but may be higher in Asian populations [6]. There is significant social and psychological impact on younger patients. These symptoms are poorly controlled with medical or topical therapy, and patients with these symptoms are good candidates for sympathectomy [5]. In this study, we evaluated the application of thoracoscopy in children for management of palmar hyperhidrosis and recorded our early experience. The study was conducted on 20 patients, 12 males and 8 females; with average age of 10 years. Our sample size was small, only 20 patients, which is accepted when compared to the few reports of hyperhidrosis in children. Our patients' average age was 10 years (range 6-14 years). The only available large series on children was by Cohen Z et al. [7], where they reported 34 children, with their age ranging from 6 to 12 years. Table 8 summary of 20 patients with hyperhidrosis.

Most of the authors reported higher age groups, for example, Zacherl had 26 patients aged from 11 to l7 years [8]. Others as Moya et al. [9] reported their experience on groups of patients aged between 22.9 to 27.4 years. In this study the male to female ratio was 3:2. This is similar to some reports in literature [10] although another study reported 1:1.5 or 1:2 ratio [11]. In our series, all patients had bilateral palmar and plantar hyperhidrosis, where 14 of them (70%) had an associated axillary hyperhidrosis. These findings are similar to those reported by Yano (63%) [12]. Villaça et al. [1] reported higher incidence of associated axillary sweating (90.7% and 83.3% respectively).

In our assessment of the degree of severity we used clinical assessment according to patient symptomatology described by hyperhidrosis disease severity scoring system (HDSS) [4]. Others used more quantitative parameters for assessment of degree of severity as measuring the amount of sweat gravimetrically on filter paper or by iodine starch test, or the ninhydrin test [13,14]. The therapeutic options for the management of hyperhidrosis have traditionally been nonoperative. These include topical astringents, absorbing powders, and anticholinergic drugs. Other methods of treatment have included biofeedback, iontophoresis, botulinum toxin, and percutaneous phenol block. These methods seldom give sufficient relief, their effects are usually transient, and they are not without associated side effects. The anticholinergics commonly cause dry mouth and blurry vision, making their long-term use undesirable. Botox (Botulinum toxin type A) is effective as treatment for axillary and palmar hyperhidrosis; however, the effects usually last only 3 to 4 months with repeated injections required. Therefore, surgical sympathectomy is assuming a larger role as primary therapy, especially in children and adolescence [15]. Twelve patients (60%) underwent unilateral sympathectomy. Eight patients (40%) underwent bilateral thoracoscopic sympathectomies at one or two stage, six at the same session (30%). We shifted from staged sympathectomy to bilateral same session surgery because we found that the recovery and results are similar. The same was reported by others [16].

The most popular example of open sympathectomy is using the transcervical route, where injury to the stellate ganglion is in fact very frequent and expected, producing significant sequelae: the so-called Claude-Bernard-Horner syndrome (palpebral ptosis, miosis and enophthalmos). In addition, injuries to the phrenic nerve and direct injury to the brachial plexus, among others, may occur. Such an incidence of complications led to restricted use of this technique (only in patients with severe ischemia) [17].

The excellent view of the ganglion, together with adequate magnification, allows for precise division of the ganglion, which results in lower incidences of Horner's syndrome (0.4% to 2.4%) when compared with open sympathectomy [18].

With the advent of video-assisted thoracoscopy, the spread of this method and its safety, thoracoscopic sympathectomy has acquired an important position in the treatment of this disease, especially in Asia and Europe. This access route, after the surgeon has acquired adequate experience through training in videoassisted thoracoscopy, allows well-directed surgery to be performed, with minimal risk of the disagreeable complications that occurred in the past when the transcervical route was used, as well as the sequelae and scars of classical thoracotomy [19].

Although open operative procedures to treat hyperhidrosis successfully resolved symptoms in more than 95% of cases [20]; yet open sympathectomy is rarely performed currently because of higher morbidity, longer operation time, and hospital stay, which led to restricted use of this technique [21].

Table 8: Summary of 20 patients with hyperhidrosis.

Pts	Age	Sex	Affection	Operative procedure	Follow up
1	7 y	♀	Palmar + plantar	Unilateral T2-3 transection + cauterization	4 months
2	10 y	♀	Palmar + axillary + plantar	Unilateral T2-3 transection + cauterization	6 months
3	10 y	♂	Palmar + axillary + plantar	Unilateral T2-4 resection	6 months
4	12 y	♂	Palmar + plantar	Unilateral T2-4 resection	4 months
5	9 y	♂	Palmar + axillary + plantar	Unilateral T2-3 transection + coagulation	Lost
6	8 y	♀	Palmar + axillary + plantar	Unilateral T2-4 resection	3 months Recurrence reoperation (aberrant nerve) Lost
7	6 y	♀	Palmar + plantar	Unilateral T2-3 transection + cauterization	3 months Recurrence (refuses reoperation)
8	11 y	♀	Palmar + axillary + plantar	Unilateral T2-3 transection + cauterization	7 months
9	9 y	♂	Palmar + axillary + plantar	Unilateral T2-4 resection	8 months
10	11 y	♂	Palmar + plantar	Unilateral T2-4 resection	4 months
11	10 y	♂	Palmar + axillary + plantar	Unilateral T2-3 transection + coagulation	Lost
12	7 y	♀	Palmar + axillary + plantar	Unilateral T2-4 resection	Lost
13	12 y	♂	Palmar + axillary + plantar	Bilateral T2-4 resection (2 separate settings)	6 months
14	11 y	♂	Palmar + axillary + plantar	Bilateral T2-4 resection (2 separate settings)	9 months
15	14 y	♂	Palmar + axillary + plantar	Bilateral T2-4 resection (same setting)	3 months
16	8 y	♀	Palmar + axillary + plantar	Bilateral T2-4 resection (same setting)	4 months
17	11 y	♂	Palmar + plantar	Bilateral T2-4 resection (same setting)	12 months
18	12 y	♂	Palmar + axillary + plantar	Bilateral T2-4 resection (same setting)	4 months
19	9 y	♀	Palmar + axillary + plantar	Bilateral T2-4 resection (same setting)	6 months
20	10 y	♂	Palmar + plantar	Bilateral T2-4 resection (same setting)	4 months

By utilizing evolved techniques for thoracic sympathectomy we can now achieve improved patient care and outcomes [22]. Previously, sympathetically mediated syndromes required highly invasive surgical procedures to resect a relatively small portion of the upper thoracic sympathetic ganglia [20].

Despite these issues, previous surgical procedures produced acceptable longterm clinical results [23]. Consequently, less traumatic and invasive procedures for sympathectomy have been sought.

Careful patient selection is essential to minimize the morbidity of thoracoscopic procedures. Although some patients may be treated by minimally invasive techniques, there are still some individual patients who are treated more safely by open thoracic surgical procedures. It is this clinical judgment by pediatric surgeons that mandates when these techniques are used on children [24].

For severe hyperhidrosis, thoracoscopic sympathectomy is the "gold standard" of treatment. The rate of improvement is usually >90%, but the rate of satisfaction and compensatory sweating varies. Different surgical techniques have been published during the last decades [25].

Hyperhidrosis is the primary indication for thoracic sympathectomy. In a study [6] involving 100 patients with hyperhidrosis, the post sympathectomy success rate was reported to be 98%, which is similar to our series (90%). Analyses of results from our current outcome study suggest that patients experienced high overall satisfaction (90%) and that they would undergo the same treatment and procedures again for the other side.

Recent advancements in video optics and specialized instrumentation have significantly facilitated sympathectomy. The sympathetic trunk can be easily identified through the parietal pleura thoracoscopically and surgical division of the trunk can be safely performed with minimal associated morbidity [26].

Our immediate success rate was 100%, which was similar to another study. There was some decrease in plantar sweating in our patients after the procedure; this comes in accordance with the studies reported by other authors [27].

The rate of satisfaction with the overall results of the operation in our series was as much as 90% [28]. Other studies reported improvement of the quality of life in 90 to 98% [29].

If possible, most authors advised the use of single lung ventilation in thoracoscopy [30]. Although we agree with them, yet this was not possible in our study because of anesthetic difficulties. We used the open technique for insertion of the first port because we believe it is safer than the use of Veress needle. This agrees with some authors [31], and differs from others [32], who prefer to use the Veress needle.

Another aspect is the positioning of the patient during the procedure. We positioned the patients in lateral decubitus position with anti-Trendelenberg tilt. Some authors prefer to position the patient supine with 20o anti-Trendelenberg tilt of the table. Both positions allow gravity to assist in revealing the spine and the sympathetic chain along with the partial lung compression using carbon dioxide insufflations. However, in bilateral cases operated upon at the same session, adopting the supine position reported a substantial shortening of the operative time [33].

We consistently used three ports for all our patients, which is in agreement with most authors. However, other authors use Bi-portal and Uniportal trans-axillary techniques with good results and better cosmoses [34].

Our operative technique has evolved with experience. A few points are worth noting. First, downsizing trocars to 5 mm has significantly diminished postoperative pain. Typical postoperative analgesic requirements are oral non-steroidal in the first 24 hr to 48 hr only. Secondly, although the procedure can be performed through open ports without CO_2 insufflation, the addition of CO_2 pressure markedly enhances visualization by displacing the lung and expediting the procedure. Thirdly, any intrathoracic air leak is immediately apparent at closure and can be easily managed by chest tube. Removal of underwater seal is usually possible within 24 hr to 48 hr. This method of air leak management has been sufficient in all patients.

Thoracoscopic excision of T2-T4 sympathetic ganglia was done in most patients with palmar hyperhidrosis. Some authors practiced clipping or clamping of the sympathetic chain with reported good results. Reisfeld et al. [35] claimed better satisfaction in patients who had clipping versus excision, at 98% versus 95.1%.

It is also reported to be safe and effective with the advantage of reversal in cases of postoperative compensatory hyperhidrosis [36]. Others prefer cauterization of the affected segment rather than mechanical resection, stating that this is easier and quicker [37]. In our series we used either resection or cauterization or combined in all cases.

Level of sympathectomy has been studied in randomized, controlled trials [38] and it was observed that T3 level sympathectomy has the same efficacy as T2 level but has lower incidence of side effects, such as compensatory sweating. In our series we used T2-T4 resection or cauterization.

Controversy exists regarding the necessary extent to which the sympathetic ganglion should be resected in patients with hyperhidrosis [39]. Resection of the T-2 sympathetic ganglion results in sympathetic denervation of the lower trunk of the brachial plexus; some authors, however, have advocated more extensive denervation that includes the T3–4 ganglia and possibly the inferior aspect of the stellate ganglion in severe cases of axillary and palmar hyperhidrosis [40]. The primary difference in patients undergoing thoracoscopic sympathectomy is the smaller surgical exposures that allow rapid recovery and return to full activity following a brief hospital stay; this alone suggests cost effectiveness.

In our series we used subcuticular skin sutures to close the skin. Others [41] used tissue glue. We find that both policies are comparable regarding operative time and costs.

Our mean operative time was about 25 (range 20 to 30) minutes in the unilateral cases and 50 (range 40 to 60) minutes in bilateral cases, similar to most of the reports in the literature [36] and longer than some [37] because surgical resection requires longer time than that needed for ablation. The mean operation times varied from 39–124 minutes as reported by another author [42].

The mean duration of hospital stay in our study was 48 hours, similar to most of the reports in the literature [43]. Our outcome concerning long-term follow up of patients with palmar hyperhidrosis was 90% complete relief of symptoms, while 10% had recurrence. Out of the 14 patients with associated axillary hyperhidrosis, 10 (72%) had complete relief of symptoms, while 4 (28%) had partial relief. Other authors reported long term success rate more than 90% [27].

Our perioperative complications concerning mortality and conversion to open thoracotomy was zero, which is similar to some authors who reported conversion and mortality to be less than 1% [29] which occur in patients mostly due to associated cardiac condition or in cases performed bilateral sympathectomy at same session due to pulmonary insufficiency as a result of lung collapse.

Reported rate of early complications by other authors was 3% to 10%; most common are Horner syndrome, recurrence, hemorrhage, and pneumothorax [44]. A small insignificant pneumothorax can be expected in 75% of patients, which gets absorbed spontaneously usually within 24 hours [45]. The rate of chest drainage for treatment of pneumothorax was found to be 0% to 8% [45].

Most complications resulting from thoracoscopic sympathectomy are minor and self limiting. None of our patients developed transient ptosis and none developed permanent lesions. However; 3% to 10% transient and the 0.28% permanent forms has been reported by different authors [46]. Horner's syndrome [20] which results from injury to the stellate ganglion is fortunately infrequent and usually transient. The improved visualization obtained by using thoracoscopy would theoretically reduce the incidence of Horner's syndrome by allowing the surgeon to identify the stellate ganglion and avoid the fibers ascending rostrally from the stellate, which innervate the ocular pupillary muscles, and dividing the rami caudal to the stellate ganglion that provides sympathetic innervations to the upper extremity [47]. Small haemothorax do not require drainage but should be followed by repeated chest X-ray films [48]. Pneumothorax indicates a parenchymal or port-site leak. A small pneumothorax can be observed, but a large one requires placement of a chest tube.

Our reported rate of pneumothorax and haemothorax was 10% similar to the reported ones of 0.5% to 9.1% [43]. We use a postoperative chest tube in all cases similar to Krasna et al. [49], who used chest tubes routinely in all patients at the end of the procedure.

Other complications, including persistent air leak requiring chest drainage and bleeding, were relatively uncommon in accordance with other series [50].

Intercostal neuralgia results from the injury of the intercostal nerves that can occur during port placement or when direct pressure is applied to the nerves during the procedure. Intercostal neuralgia did not occur in any of the patients in this series, which may be due to several factors. Soft flexible ports are now used exclusively. Our current use of a 5-mm-diameter endoscope may further reduce the incidence of intercostal neuralgia. Hashmonai and colleagues have cited a lower incidence of intercostal neuralgia as the major difference between open supraclavicular and endoscopic sympathectomy procedures; however these differences may only reflect the use of flexible ports and smaller instruments [51].

Neuralgic pain and/or paresthetic sensation at the thoracic wall occurred rather less frequently. Postoperative pain measurement was beyond the scope of this study. The majority of our patients tolerated postoperative pain conservatively with simple oral non-steroidal analgesics and no nerve therapy was required. This pain was a distressing symptom in two patients only (10%). The symptomatology subsided completely at a maximum of three months.

Brachial plexopathy and chylothorax was not encountered in any case. Other specific complications such as intercostal neuralgias, injury to the subclavian vessels or the esophagus have not been reported in this study.

The emergence of complications varies from one series to the next. The percentage of complications in our study was 0%, concerning infection at incision site, residual pneumothorax, and hypertrophic scar formation. We believe that, once the technique has been mastered and refined, both the complication rate and morbidity should be quite low.

Another side effect is excessive dryness of the hands. This condition refers to excessively dry hands that necessitate the use of hand cream daily. Although the incidence of excessive dryness ranges from 9% as reported by some authors (156) to 51% as reported by others [29] none of our patients suffer from this complication.

Recurrence rate was in two cases (10%) treated by cauterization, which is similar to 0% to 14% reported by some authors [42]; but slightly higher than 3% reported by others [52] who use excision rather than cauterization of sympathetic ganglia. So overall, we think that resection of the sympathetic chain rather than cauterization helps to decrease the incidence of recurrence, yet it might be associated with longer operative time and higher incidence of excessive dryness, which is usually well tolerated by the patients.

Compensatory hyperhidrosis was evaluated by contacting patients for a minimum follow-up evaluation of 3 months. The patients were contacted by telephone, and a specific asking during another consultation. However, when the degree of sweating in different body regions was compared according to the preoperative and postoperative evaluation, only eight cases showed changes in the degree of sweating. The body regions with significant changes in sweating were the trunk and feet (increased sweating), the other side in six patients (reduced sweating).

The delayed complication of compensatory hyperhidrosis varies among the reported series, ranging from 12% to 45% [48]. Compensatory hyperhidrosis occurred in approximately 40% of patients in our series, which is consistent with earlier reports. Thoracoscopic techniques may not change this, but only the outcomes of further studies will determine this. A remarkably small number of patients with compensatory symptoms are dissatisfied when they compared these with their previous symptoms of palmar sweating. There is a tendency for this symptom to diminish over a period of one year or more after surgery.

Compensatory sweating is, without a doubt, one of the most troublesome postoperative side effects for all patients. Perhaps this is why numerous surgeons have begun to search for the ideal technique to significantly reduce the percentage of cases developing compensatory sweating.

Riet et al. [53], in a paper published in 2001, showed that compensatory sweating was nonexistent after limiting thoracoscopic sympathectomy to the third ganglion.

Compensatory hyperhidrosis was not of significant importance to any of our patients, regardless of the number of ganglia removed. The reported rates of postoperative compensatory hyperhidrosis vary widely in the literature. Some authors reported rates as low as 1.2% to 6% [36], others reported an intermediate rate of 50% [9], while others reported rates as high as 85% to 86% [46].

Some authors report a gradual decrease in the grade of intensity of compensatory sweating during a longer follow-up period [54]. Compensatory sweating is mostly located at the trunk or lower limbs as in our trial [55]. The rate of compensatory sweating is said to be the marker of quality of sympathectomy [44], others consider not [53].

The rate of compensatory sweating was found to be 2% to 5% after resection of T2-4, 0% after resection of T2, and 3.6% after T3/T2-3 resection [56]. Schmidt and colleagues found a significantly lower rate of compensatory sweating after resection from T3-T5 compared with resection from T2-T4 [44]. Other authors stated that axillary hyperhidrosis requires resection as far as T4 [57]. Additional resection from T4-T5 was said to improve the results for armpit hyperhidrosis [58]. A limited resection of T4/5 as described by Hsu and colleagues offers good result in 86%, with compensatory sweating in only 29% [57]. Some authors suggest saving the sympathetic trunk and selectively blocking the communicating branches and postganglionic fibers (Wittmoser procedure) [45].

Some authors suggest the resection of the second and third ganglion to achieve anhidrosis of the hands. The resection of the fourth ganglion was suspicious to be the reason for compensatory sweating [59].

Kopelman et al. [61] found a rate a compensatory sweating of only 5.8% after preservation of the fourth ganglion [60]. Therefore, some authors advocate a limited resection. There is no evidence concerning the extent of dissection or resection so far [62]. Interestingly >90% of patients with compensatory sweating were satisfied with the results of the operation [29]. Other authors pointed out that the rate of compensatory sweating is not related to the extent of sympathectomy if it is not beyond the fourth ganglion. The reason for the compensatory sweating might be ineffective sympathectomy or prone to surgical failure [63].

By analyzing the influencing factor of overall satisfaction, we could confirm the impact of the intensity of compensatory sweating next to the improvement of symptoms, whereas gustatory sweating has no statistically proven impact. In some studies the rate of improvement and satisfaction were lower in the axillary group compared with the palmar group (83% *vs.* 100% and 67% *vs.* 93%, respectively) [55].

Our technique involves limited excision of the ganglia at T2-T4. Methods described for performing sympathectomy include simple transection of the sympathetic ganglion, ablation with cautery or laser, or simple clipping of the sympathetic chain with titanium clips. Clipping of the sympathetic chain, without division or ablation, allows the theoretical advantage of reversal should the symptoms of compensatory sweating become unbearable. However; we used transection in most cases. In our experience, the desire for reversibility was zero. Irrespective of the chosen method of sympathetic chain disruption, the success rates as well as the incidence of postoperative compensatory sweating are quite similar. In the majority of patients in our study the compensatory sweating was only a minor inconvenience compared with their preoperative symptoms and our overall satisfaction rate for the procedure at 3-6 months follow-up was 90%. When compensatory hyperhidrosis is moderate or severe, management is difficult and generally unsatisfactory.

Gustatory sweating was reported in 1% to 30% of patients by some authors. None of our patients suffers this complication. It might be caused by an aberrant anastomosis between sympathetic trunk and the vagal nerve [48].

Taking in consideration our small sample size and limited period of follow up, we recommend to apply this study on a larger scale including larger number of cases with longer follow up period for better evaluation of results.

Conclusion

Endoscopic sympathectomy is a safe and effective treatment for severe palmar hyperhidrosis. There is a significant incidence of compensatory sweating after sympathectomy and this is sufficiently troublesome in some patients for them to regret surgery. The best level for sympathectomy and the technique used to interrupt the sympathetic chain remain the subject of debate. There is growing evidence that limited sympathectomy (T3 or T4 level) is effective for palmar hyperhidrosis with a lower incidence of compensatory sweating than conventional T2 sympathectomy. The results of sympathectomy for isolated axillary hyperhidrosis are frequently unsatisfactory. We concluded that thoracoscopy has become adopted widely by pediatric surgeons and is currently considered to be the optimum technique for management of hyperhidrosis in pediatric patients. In conclusion, in view of the low morbidity and zero mortality rate of this surgical technique, we recommend it as a method of treatment for palmar hyperhidrosis. Thoracic sympathectomy eliminates palmar hyperhidrosis with minimal recurrence (10% in our series). Although the percentage of compensatory sweating is high (in some cases it tends to decrease spontaneously), it produces a high rate of patient satisfaction.

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