Endoscopic thoracic sympathectomy

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Object. Thoracic sympathectomy has evolved as a treatment option for patients with hyperhidrosis and pain disorders. In the past, surgical procedures were highly invasive and caused significant morbidity, but the minimally invasive thoracoscopic procedure provides detailed visualization of the sympathetic ganglia and is associated with minimal postoperative morbidity.

Methods. The authors performed 112 thoracoscopic sympathectomy procedures in 65 patients, and the outcomes were equivalent to those previously established for open surgical techniques; however, the rate of surgery-related morbidity, length of hospital stay, and time until return to normal activity were substantially reduced. Complications and recurrence of symptoms were comparable with those demonstrated in previous reports. Overall patient satisfaction and willingness to undergo a repeated operative procedure ranged from 66 to 99%. Postoperatively, higher satisfaction rates were observed in patients with hyperhidrosis whereas in those with pain syndromes, satisfaction rates were lower.

Conclusions. Minimally invasive thoracoscopic sympathectomy procedures are useful in treating sympathetically mediated disorders, and the results indicate that the procedure is associated with reduced morbidity and similar outcome when compared with results obtained after open surgery. Hyperhidrosis is well treated, but patients with pain syndromes have significantly poorer outcomes.

KEY WORDS • thoracoscopy • sympathectomy • hyperhidrosis • Raynaud’s syndrome • causalgia • reflex sympathetic dystrophy • complex regional pain syndrome

In the past decade, video-assisted endoscopic imaging has made minimally invasive procedures technically feasible. Treatment of sympathetically mediated syndromes affecting the upper extremity including hyperhidrosis, pain syndromes (causalgia, also known as reflex sympathetic dystrophy [RSD], now commonly referred to as complex regional pain syndrome [CRPS]), and Raynaud’s syndrome, are the primary indications for thoracoscopic sympathectomy.1,3,8,11,12,22,25 Thoracoscopy provides a magnified view of the sympathetic chain and adjacent anatomy for precise surgical resection of the sympathetic ganglia, and it avoids the morbidity associated with open thoracotomy, supraclavicular, and paraspinal procedures.11,23 Because length of hospital stay (LOS) and morbidity rates are reduced, patient satisfaction is improved, which now makes thoracoscopic sympathectomy the preferred procedure for these disorders; however, long-term outcome studies have been limited.

Clinical Material and Methods

Patient Population

During a 6-year period between 1993 and 1999, 65 patients underwent 112 thoracoscopic sympathectomy procedures for sympathetically mediated disorders. These procedures were performed for uni- or bilateral symptoms. Twenty patients underwent a unilateral thoracoscopic sympathectomy procedure, and 11 patients with bilateral symptoms underwent staged thoracoscopic procedures several weeks apart in the early phase of the series (1993–1995). During the most recent 4-year period, 34 patients with bilateral symptoms have undergone sequentially staged thoracoscopic procedures on the same day.

Indications and General Considerations

Patients with sympathetically mediated syndromes, such as hyperhidrosis, CRPS, RSD, and Raynaud’s syndrome, in whom medical treatment failed to relieve symptoms underwent sympathectomy. Imaging studies such as chest radiography and computerized tomography or magnetic resonance imaging of the cervical and thoracic spine and brachial plexus were not necessarily performed in each case. Psychological evaluation, an important component in the evaluation of patients with chronic pain, was performed as well. Stellate ganglion anesthetic blocks were used to obtain diagnostic confirmation that symptoms would be responsive to sympathetic blockade in patients with pain and ischemic disorders and only in a limited number of patients with hyperhidrosis.

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Intubation and Positioning

General anesthesia was induced, and patients underwent selective intubation, with single-lung ventilation being required for patients in whom a thoracoscopic sympathectomy was to be performed. Positioning of the patient during the procedure has evolved during the present series (Table 1). Early in the series, patients underwent surgery while in a lateral position with the side in which surgery was to be performed facing up (Fig. 1); in patients with bilateral symptoms surgery was performed on the opposite side several weeks later. Later in the series, those patients with bilateral symptoms who were undergoing bilateral sympathectomies were repositioned for an immediate second-stage procedure on the contralateral side. Currently, in patients requiring bilateral sympathectomies the procedure is performed while the patient is supine to obtain exposure of both axillary regions in immediately staged procedures (Fig. 2).

Equipment and Instruments

The equipment and instruments required to perform a thoracoscopic sympathectomy are available in most operating rooms. A 5- to 10-mm-diameter rigid endoscope (with 0-, 30-, and 60°-angled lenses) with a camera and video monitor are required for visualization. Endoscopic instrumentation includes a 5-mm-diameter mini-Metzenbaum-type scissors with monopolar cautery, a 10-mm curved hemostat grasper, and a 5-mm-diameter suction/irrigation device.

Ports and Placement

Three ports are used but occasionally only two are needed. Port placement and location are important for good endoscopic visualization and manipulation of the instruments during the procedure. The endoscope is placed in one port, and the instruments are placed in the remaining ports (Fig. 3). The port is inserted into the intercostal space, similarly to chest tube placement, through a 2-cm skin incision, avoiding the neurovascular bundle. A 15-mm Flexi-Port (Ethicon Inc, Cincinnati, OH) is inserted using a blunt introducer. The ipsilateral lung is deflated by the anesthetist. The endoscope port is placed in the third or fourth intercostal space in the midaxillary line, and the instrument ports are placed in the fifth or sixth intercostal space. Additional ports can be placed for lung retraction or to assist in the procedure as needed.

Steps in the Procedure

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 (Fig. 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 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 intercostal veins should be avoided during the dissection of the sympathetic chain.

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 (Fig. 5). The scissors are then used to dissect the sympathetic chain from its bed by dividing the rami communicantes at each level (Fig. 5 left). The creation of a dissection plane immediately beneath the sympathetic chain avoids the underlying inter-
costal 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 (Fig. 5 right) within the fat pad. 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 one of the ports, and the lung is reinflated by the anesthetist. The port incisions are closed in two layers.

Postoperative Care

The chest tube is initially adjusted to negative 15-cm water suction, and an immediate chest x-ray film is obtained to verify proper inflation of the lung. The chest tube is removed the same day. Administration of oral analgesic agents is adequate for pain control, and the patient is discharged when ambulatory.

Outcome Analysis

The follow-up period was 6 months to 6 years, with annual clinic evaluations of all patients. Patient data were obtained from clinical examination and/or telephone interview. Clinical outcome questionnaires were collected and retrospective analysis was performed.

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. Patients with pain disorders were evaluated with the Oswestry Pain Scale to determine outcomes and to quantify the severity of their symptoms pre- and postoperatively. Outcome data was solicited by an independent observer. 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

The largest group of patients were those with hyperhidrosis (Table 2) who underwent thoracoscopic sympathectomy, and they also had the highest success rates (Tables 3 and 4). Also in this group the highest complication rates were demonstrated, most often related to compensatory hyperhidrosis (manifesting as sweating in the trunk/torso or gustatory sweating); however, most patients were sufficiently satisfied with the postoperative result. Patients treated for pain syndromes or vasculitic disorders are noted in Table 2 and their initial response to treatment was very positive; however, the effectiveness of treatment diminished after more than 6 months postoperatively (Tables 4–6), and the recurrence of symptoms was variable in these patients. Symptoms did not worsen in any patient who underwent sympathectomy, and the causes of symptom recurrence are unknown. Their overall satisfaction and willingness to repeat the operative treatment was correspondingly decreased (Table 4).

The LOS was short for those patients who underwent thoracoscopic sympathectomy: most patients remained 1 or 2 days postoperatively (Table 4). In historical cohorts of patients at our institution who underwent posterior paraspinous sympathectomies LOS ranged from 3 to 6 days. The overall complication rates (Table 8) were comparable with previous treatment modalities.

Discussion

Evolution of Sympathectomy Techniques

By utilizing recently evolved techniques for thoracic sympathectomy we can now achieve improved patient care.
and outcomes.3,7,15,18,19 Previously, sympathetically mediated syndromes required highly invasive surgical procedures to resect a relatively small portion of the upper thoracic sympathetic ganglia.2,4,6,10,29,31,32 Despite these issues, previous surgical procedures produced acceptable long-term clinical results.2,4,6,10,27,32 Open operative procedures to treat hyperhidrosis successfully resolved symptoms in more than 95% of cases, and patients with pain disorders have had long-term improvement that is successful in only 60 to 80% of cases.6,23,29,32 Consequently, less traumatic and invasive procedures for sympathectomy have been sought.

History of Thoracoscopy Procedures

Thoracic endoscopic procedures were first performed in 1910 by Jacobaeus14 for the diagnosis of intrathoracic infectious and neoplastic diseases. The first thoracic endoscopic procedure for a sympathetic ganglionectomy was performed in 1942 by Hughes.13 Kux18 published his initial paper on endoscopic procedures involving the “vegetative” nervous system in 1951 and then published his large series19 of more than 1400 endoscopic sympathectomies and vagotomies in 1954. In these early series, the indications for sympathectomy were diverse; they included angina, hypertension, and gastric ulcers, as well as hyperhidrosis and vasculitic/pain disorders.18–20 Medical management has reduced the number of current indications for sympathectomy to hyperhidrosis and pain disorders, and most reports in the past decade reflect the resurgence of interest in thoracoscopic treatment of these disorders.1,3,14,17,24,30 Similarly, public interest in minimally invasive surgery has increased because of shortened LOS, which has brought to light the relatively high incidence of these benign disorders.

Treatment for Hyperhidrosis

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.5,23,27,33 There is significant social and psychological impact on younger patients, and the condition may also have important economic and occupational implications for older patients. These symptoms are poorly controlled with medical or topical therapy, and patients with these symptoms are good candidates for sympathectomy. Stellate ganglion blocks are useful in preoperative evaluation and result in a dramatic decrease in sweating and warming of the hand due to decreased sweat gland activity and increased blood flow through cutaneous arteriovenous fistulas.3 Controversy exists regarding the necessary extent to which the sympathetic ganglion should be resected in patients with hyperhidro-
sis.\textsuperscript{10,12,23} 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.\textsuperscript{3,10,11,22,30} 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.

Hyperhidrosis is the primary indication for thoracic sympathectomy. In a recent study\textsuperscript{27} involving 100 patients with hyperhidrosis, the postsympathectomy success rate was reported to be 98\%, which is consistent with our series. In a small prospective trial\textsuperscript{11} of open supraclavicular compared with thoracoscopic sympathectomy for the treatment of hyperhidrosis, the investigators achieved equivalent results but concluded that open surgery may be preferable because of chest wall discomfort in patients undergoing thoracoscopy; however, the trial lacked convincing statistical support with objective data. Analyses of results from our current outcome study suggest that patients experienced high overall satisfaction and that they would undergo the same treatment and procedures again.

The delayed complication of compensatory hyperhidrosis varies among the reported series, ranging from 12 to 45\%.\textsuperscript{11,21,30} Compensatory hyperhidrosis occurred in approximately 22\% 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.

### Treatment for Pain Syndromes

Dysesthetic pain syndromes likely arise from peripheral nerve or extremity injuries, causing the poorly understood

### TABLE 2

<table>
<thead>
<tr>
<th>Diagnosis in patients undergoing thoracoscopic sympathectomy</th>
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<tr>
<td>Disorder</td>
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<tr>
<td>----------</td>
</tr>
<tr>
<td>hyperhidrosis</td>
</tr>
<tr>
<td>RSD/CRPS</td>
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<tr>
<td>Raynaud’s syndrome</td>
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### TABLE 3

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Relief of Symptoms</th>
<th>Partial Relief of Symptoms</th>
<th>Recurrent Symptoms*</th>
<th>Lost to Follow Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>hyperhidrosis</td>
<td>47</td>
<td>1</td>
<td>0*</td>
<td>0</td>
</tr>
</tbody>
</table>

* Although no patients experienced recurrent palmar hyperhidrosis, 11 patients had mild compensatory sweating in the trunk and two patients suffered gustatory sweating.
syndromes of RSD and CRPS. Other sympathetically mediated pain syndromes include phantom pain, shoulder–hand syndrome, and postherpetic neuralgia.13,23 Characteristic symptoms are typically a constant burning pain exacerbated by tactile stimulation and trophic skin changes. Medical therapy in which narcotic, neuroleptic, and/or anticonvulsant drugs are used has limited long-term efficacy, although it can be used to augment an aggressive rehabilitation effort, which is the first line of treatment. Stellate ganglion blocks can be used to provide temporary relief for days or weeks while rehabilitation therapy is ongoing. Patients with good responses to stellate blocks but in whom rehabilitation efforts fail may be candidates for surgical treatment.1

Ablative surgical procedures such as rhizotomy and cordotomy are complex, technically demanding, and often produce limited efficacy, high recurrence rates, and involve significant potential for complications. The sympathectomy procedure in selected patients offers remarkable symptomatic improvement; however, some patients (10–25%) may suffer symptom recurrences that vary in severity.1,1221 Patient selection likely plays an important role in the surgical outcome; ideal candidates have only dystrophic symptoms that have not progressed to chronic atrophic changes.1,12 Although the causes of recurrent pain symptoms are unclear, they may, some investigators have postulated, be related to incomplete denervation and the regrowth of the sympathetic ganglion or receptors.1,21 The results of our current study do not indicate better outcomes than those obtained in previous reports, but further study is needed to determine if the extent of sympathetic chain resection plays a role in long-term outcomes.

**Treatment for Vasculitis and Raynaud’s Syndrome**

Raynaud’s syndrome is the most common vasculitic disorder that causes ischemic pain in the hands and fingertips.

### TABLE 4

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Patient Satisfaction Rate (%)</th>
<th>Willingness to Repeat (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>hyperhidrosis</td>
<td>96</td>
<td>98</td>
</tr>
<tr>
<td>RSD/vasculitis</td>
<td>66</td>
<td>65</td>
</tr>
</tbody>
</table>

### TABLE 5

<table>
<thead>
<tr>
<th>Disorder</th>
<th>No. of Patients</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Relief of Symptoms</td>
</tr>
<tr>
<td>RSD/CRPS (12 patients)</td>
<td>7</td>
</tr>
<tr>
<td>Raynaud’s syndrome/vasculitis (5 patients)</td>
<td>4</td>
</tr>
</tbody>
</table>
It is usually associated with collagen vascular diseases, and extreme cases result in ulceration of the digits. These symptoms are typically exacerbated by cold temperatures or emotional responses, and the primary treatment is to avoid the cold. Medical therapy in which calcium channel blockers and alpha–adrenergic blocking agents are used is recommended, and it is often effective in most cases.22 Patients with severe symptoms may respond to stellate blocks and may experience good relief of symptoms post-sympathectomy; however, results are controversial because of the variable recurrence of symptoms.9,22 Despite successful reduction of pain and low recurrence rates in our study, the small number of patients does not allow us to make further conclusions. The reason for the significant failure rate is that vasculitic syndromes are considered systemic disorders that may not respond to regional or local surgical treatment, and some authors are firmly opposed to sympathectomy for the treatment of Raynaud’s syndrome.9,22 Regardless, our results indicate that some proportion of patients with Raynaud’s syndrome may respond to sympathectomy and determining the criteria for patient selection remains difficult and unclear at this time.

Thoracoscopy-Related Complications

Most complications resulting from thoracoscopic sympathectomy are minor and self-limiting. Whereas Horner’s syndrome occurred more frequently in the early years of this series, there were fewer occurrences in the patients treated later, which may reflect the learning curve for surgical techniques. Horner’s syndrome,3,11,28 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 innervation to the upper extremity.28

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 also occurred more frequently in those patients treated earlier in the series and less frequently in those treated later, 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 colleagues11 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.

Small pleural effusions do not require drainage but should be followed by repeated chest x-ray films.3,11,22 Pneumothorax indicates a parenchymal or port-site leak. A small pneumothorax can be observed, but a large one requires placement of a chest tube.

The one death in our series occurred several weeks after surgery; the patient had known risk factors but was otherwise doing well postsurgery. Cardiac function and catecholamines are not significantly changed following sympathectomy, and they are unlikely to have clinically significant cardiac and hemodynamic alterations.25–28

Conclusions

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 LOS are substantially reduced when utilizing these newer techniques. We recommend that surgeons receive formal training in these procedures, with didactic and laboratory training, followed by work with an experienced surgeon who performs these procedures on a regular basis.

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