Robotic Selective Postganglionic Thoracic Sympathectomy for the Treatment of Hyperhidrosis

Hans Coveliers, MD, Mark Meyer, MD, Farid Gharagozloo, MD, Willem Wisselink, MD, PhD, Jan Rauwerda, PhD, Marc Margolis, MD, Barbara Tempesta, CRNP, and Eric Strother, CSA

Department of Vascular Surgery, VU University Medical Center, Amsterdam, The Netherlands; Washington Institute of Thoracic and Cardiovascular Surgery, The George Washington University Medical Center, Washington, DC; and Division of Cardiothoracic Surgery, Department of Surgery, University of Arizona College of Medicine, Tucson, Arizona

Background. **The surgical management of hyperhidrosis is controversial. Robotic surgical systems with their high-definition magnified 3-dimensional view and increased maneuverability in a confined space may facilitate the technique of selective sympathectomy (ramicotomy). We present a case series of patients undergoing selective postganglionic thoracic sympathectomy using robotic technology.**

Methods. **This study is a case series analysis of patients who underwent selective postganglionic thoracic sympathectomy from July 2006 to November 2011. The operation was performed on a video-assisted thoracoscopic surgery (VATS) platform. The robot was used for pleural dissection and division of the postganglionic sympathetic fibers and the communicating rami. The success of sympathectomy was assessed by intraoperative temperature measurement of the ipsilateral upper extremity, patient interviews, and scoring of the symptomatic nature of hyperhidrosis based on the Hyperhidrosis Disease Severity Scale.**

Results. **There were 110 sympathectomies performed in 55 patients (25 men, 30 women). Simultaneous bilateral sympathectomy was performed in all patients. Median age was 28 years (range, 16 to 65 years). There was no conversion to thoracotomy. Complications were minor and were seen in 5 of 55 patients (9%). There were no deaths. Median hospital stay was 1 day (range, 1 to 4 days). Of the 55 patients, 53 (96%) had sustained relief of their hyperhidrosis at a median follow-up of 24 months (range, 3 to 36 months), and compensatory sweating was seen in 4 patients (7.2%).**

Conclusions. **Robotic thoracoscopic selective sympathectomy is an effective, feasible, and safe procedure with excellent relief of hyperhidrosis and low rates of compensatory sweating and complications.**

(Ann Thorac Surg 2013;95:269–75)

Hyperhidrosis is defined as excessive sweating in response to heat or emotional stimuli beyond physiologic need. The cause of this disease is unknown, but it is theorized to be a result of overactivity of the central sympathetic nervous system. More than 7.8 million people in the United States are affected with this disease [1].

Management of hyperhidrosis includes nonsurgical and surgical therapy. Surgical management of hyperhidrosis is associated with a number of controversies, including the appropriate surgical approach, ganglionectomy vs selective sympathectomy (ramicotomy), and the extent of the sympathectomy. Presently, video-assisted thoracoscopic surgery (VATS) is the most common approach. The most preferred technique with this approach is to excise the second and third ganglia for palmar hyperhidrosis and the second, third, and fourth ganglia for axillary hyperhidrosis [2–4].

Accepted for publication Aug 2, 2012.

Address correspondence to Dr Meyer, Washington Institute of Thoracic and Cardiovascular Surgery, The George Washington University Medical Center, 2175 K St NW, Washington, DC 20037; e-mail: meyerma@gwu.edu.

Success rates are generally higher for palmer hyperhidrosis, with a rate of 95% to 97% [5–7]. Axillary hyperhidrosis is alleviated in approximately 60% to 80% [5, 6] of patients and facial flushing in approximately 75% [8]. However, a number of complications result from sympathectomy for hyperhidrosis syndromes. Compensatory hyperhidrosis is seen in 50% to 97% of patients [9–13], gustatory sweating is reported in 32% to 49% [6,9, 14], and Horner's syndrome is seen in 1% to 2.4% [5, 9, 14].

Historically, the best results to date in compensatory hyperhidrosis have been reported by Friedel and colleagues [5, 15, 16] (2.5%) and were obtained with transthoracic selective sympathectomy. As opposed to ganglionectomy, this technique divides the efferent postganglionic fibers (rami), which emanate from the second, third, and fourth sympathetic ganglia and travel to the upper extremity [5, 17, 18]. Lee and colleagues [19] reported a prospective comparison of patients who underwent T2 sympathicotomy vs T3 ramicotomy for palmar hyperhidrosis. Although patient satisfaction was similar between the two groups in this series, compensatory hyperhidrosis was approximately two-thirds lower in the group that underwent T3 ramicotomy [19].

Published by Elsevier Inc

0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2012.08.013

Table 1. Hyperhidrosis Disease Severity Scale

A	Sweating is never noticeable and never interferes with daily activities
B	Sweating is tolerable and sometimes interferes with daily activities
C	Sweating is barely tolerable and frequently interferes with daily activities
D	Sweating is intolerable and always interferes with daily activities

Selective postganglionic sympathectomy (ramicotomy) is cumbersome using conventional videoendoscopic techniques. The difficulties are due to the 2-dimensional visualization and restricted instrument maneuverability. Robotic surgical systems have the advantage of magnified high-definition 3-dimensional visualization and increased instrument maneuverability in a confined space and, therefore, may facilitate selective postganglionic sympathectomy. We present a case series of patients undergoing selective postganglionic thoracic sympathectomy using robotic technology.

Material and Methods

This study is a case series analysis of patients who underwent robotic selective sympathectomy (ramicotomy) consecutively at the VU University Medical Center from July 2006 to November 2011. This study was reviewed and determined to be exempt from Institutional Review Board approval under 45 CFR 46.101 (b) (4)

Indication for sympathectomy was persistent hyperhidrosis with no apparent cause for greater than 6 months despite medical management. Patients with palmar, axillary, and combined palmar and axillary hyperhidrosis were included in this study. Contraindication to selective sympathectomy was previous operation on the sympathetic chain. Preoperatively, patients were seen in the clinic and given a score from A to D based on the Hyperhidrosis Disease Severity Scale (Table 1).

Operative Technique

The operation is performed on a VATS platform. The robot is used for pleural dissection and division of the efferent postganglionic sympathetic and communicating fibers. The operation is performed in two phases, as described previously [20].

Phase I: Setup and Entry

An intraoperative temperature probe is placed on the palmar surface of the ipsilateral upper extremity. The temperature is recorded before and after division of the sympathetic fibers. A temperature increase of at least 0.8°C is used as the indicator for successful division of the fibers. General anesthesia is used, and the patients are placed in lateral decubitus position with the affected side up.

Three, 2-cm incisions are used. A line is drawn connecting the tip of the scapula to the costal arch. Incision 1 is placed one-third the distance superiorly from the costal arch in the intercostal space. Incision 2 is located at the anterior axillary line 2 interspaces superior to incision 1. Incision 3 is located at the anterior axillary line 2 interspaces superior to incision 2. A fourth, 1-cm incision (incision 4) is placed at the anterior axillary line 1 interspace inferior to incision 1. This incision is used intraoperatively for a lung retractor (Endopaddle Retract, Auto Suture, Covidien Inc, Mansfield, MA) and postoperatively for chest tube placement (Fig 1). The lung retractor is placed in incision 4 and is used to retract the lung medially away from the chest wall.

Phase II: Robotic Selective Postganglionic Sympathectomy (Ramicotomy)

The robot is brought in from over the head of the bed at a 30-degree angle to the longitudinal axis. The camera port (Endoeye Videoscope, Olympus America Inc, Center Valley, PA) is placed in incision 2, the right robotic arm is placed in incision 3, and the left robotic arm is placed in incision 1. The robotic endograsper is placed in the left arm and the robotic hook cautery is placed in the right arm. The sympathetic chain is identified. Ribs 2, 3, and 4 are marked with electrocautery. The pleura immediately

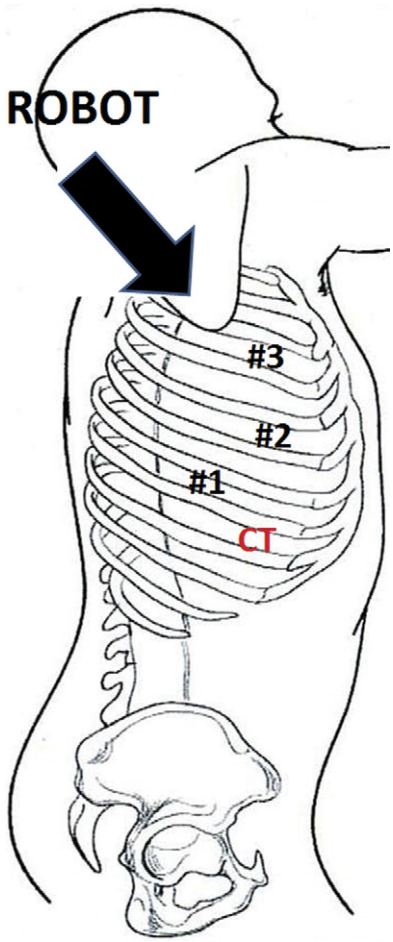

Fig 1. Numbers 1, 2, and 3 indicate incisions for port placement and robot positioning. CT indicates incision 4 for the chest tube.

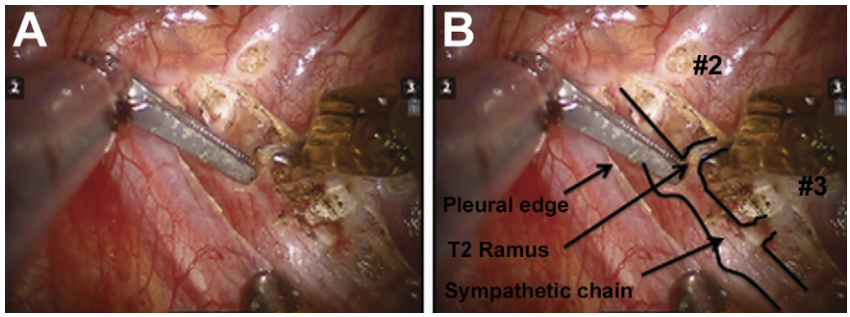

Fig 2. Intraoperative photograph, (A) without and (B) with labels, depicts the division of the left T2 postganglionic nerve arising from the sympathetic chain. Labels #2 and #3 indicate 2nd and 3rd ribs, respectively.

overlying the sympathetic chain is dissected from the second rib to the fourth rib. The postganglionic rami from T2 to T4 are divided (Fig 2). All accessory communicating fibers and the nerve of Kuntz are divided, which is accomplished by clearing the tissues lateral to the sympathetic chain. The extent of the lateral dissection is approximately 2 to 3 cm.

Sympathectomy is judged to be adequate when the palmar temperature has increased at least 0.8°C. At the completion of the procedure, the robot arms are removed from the patient and a 16F chest tube is placed in incision 4. Subpleural intercostal pain catheters (i-Flow Inc, Lake Forest, CA) are used for pain management. Incisions are closed, and selective thoracic sympathectomy is repeated in a similar fashion on the contralateral side. The patient is extubated in the operating room.

Data Analysis

The data were prospectively accrued and retrospectively analyzed. Data points analyzed included indications for operation, patient age and sex, preoperative and postoperative Hyperhidrosis Disease Severity Scale, operative time, palmar temperature measurements, morbidity, death, compensatory hyperhidrosis, and gustatory sweating. Compensatory hyperhidrosis was defined as the presence of new sweating, which was not present preoperatively, in a different part of the body. The presence of compensatory hyperhidrosis and gustatory hyperhidrosis was based on the subjective reporting of the patient.

Immediately after the operation, relief of symptoms, satisfaction with the operation, and occurrence and intensity of compensatory sweating were evaluated using a standard questionnaire and the Hyperhidrosis Disease Severity Scale. Further follow-up was conducted at 3 months and at 1, 2, and 3 years after the operation. At the time of follow-up, relief of symptoms, satisfaction with the operation, and occurrence and intensity of compensatory sweating were evaluated using a standard questionnaire and the Hyperhidrosis Disease Severity Scale.

Results

There were 110 sympathectomies performed in 55 patients (25 men, 30 women). All patients underwent simultaneous bilateral robotic selective postganglionic thoracic sympathectomy (ramicotomy). Median age was 28 years (range, 16 to 65 years). All patients (100%) had a preoperative Hyperhidrosis Disease Severity Score of D. Indications for sympathectomy in the 55 patients were palmar hyperhidrosis in 36 (65%), axillary hyperhidrosis in 7 (13%), and combined axillary and palmar hyperhidrosis in 12 (22%).

Median operative time (bilateral) was 80 minutes (range, 40 to 260 minutes). There was no conversion to thoracotomy.

Complications in the 55 patients included transient unilateral Horner's syndrome in 1 (1.8%), unilateral dysesthesia of the right hand in 1 (1.8%), transient unilateral isolated ptosis in 1 (1.8%), and bradycardia in 2 (3.6%). There was no permanent Horner's syndrome.

Median hospital stay was 1 day (range, 1 to 4 days). There were no deaths.

Overall Results

The results of sympathectomy were the same for both upper extremities in all patients. Whereas all 55 patients had a score of D preoperatively, at a median follow-up of 24 months (range, 3 to 36) months, 53 patients had a score of A and 2 had a score of D. The overall resolution of hyperhidrosis was 53 of 55 (96%). Compensatory sweating was seen in 4 patients (7.2%), and gustatory sweating was seen in 1 (1.8%).

Palmar Hyperhidrosis

The 36 patients in the subgroup with palmar hyperhidrosis all had a sustained reduction of symptoms. Compensatory sweating was seen in 3 patients (8.3%), and gustatory sweating was seen in 1 (2.8%).

Axillary Hyperhidrosis

In the subgroup of 7 patients with axillary hyperhidrosis, 5 (71%) had a sustained reduction of symptoms, and 2 (28.6%) did not have a sustained reduction of symptoms. No patients reported compensatory or gustatory sweating.

Palmar and Axillary Hyperhidrosis

In the subgroup of 12 patients with palmar and axillary hyperhidrosis, all patients (100%) had a sustained reduction in symptoms. Compensatory sweating was seen in 1 patient (8.3%). No patients reported gustatory sweating.

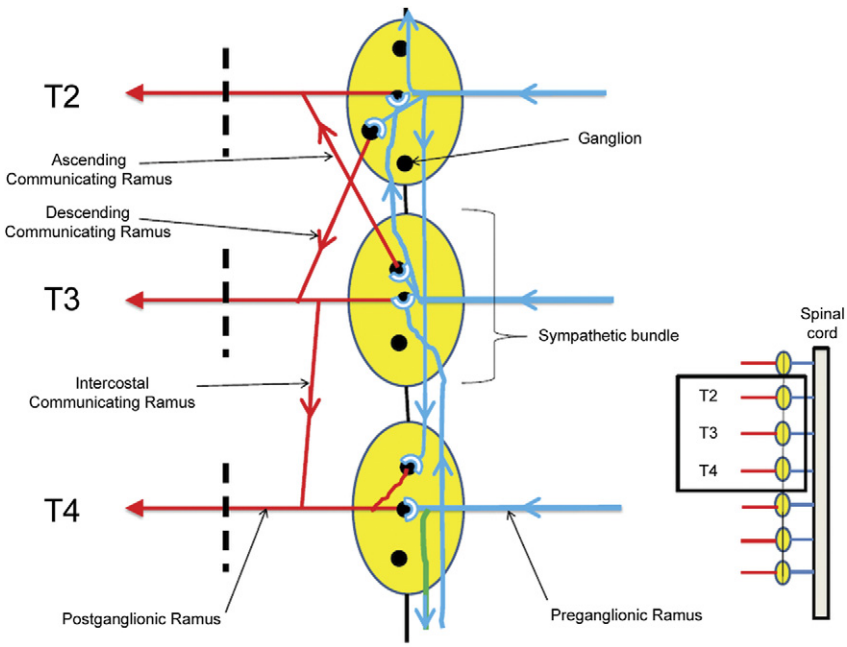

Fig 3. Diagram of the sympathetic chain from T2 to T4, which is a magnified view of the inset diagram as outlined by the box. Preganglionic fibers (blue) arise from the spinal cord and synapse via a ganglion (black) within the sympathetic chain to postganglionic fibers (red). A mixture of ganglia and interganglionic nerve fibers comprise the sympathetic bundle (yellow). Ascending communicating rami travel from the sympathetic ganglia to the intercostal nerve located superiorly. Descending communicating rami travel from the sympathetic ganglia to the intercostal nerve located inferiorly. Intercostal communicating rami travel between the intercostal nerves.

Comment

In 1920 Kotzareff [9, 21] reported sympathectomy for the treatment of hyperhidrosis. The thoracoscopic approach was described by Hughes [9, 22] in 1942. Presently, the operative management of upper extremity hyperhidrosis is associated with a number of controversies, including the surgical approach, ganglionectomy vs selective sympathectomy, and the extent of sympathectomy. Reported surgical approaches have included transthoracic, transaxillary, supraclavicular, paravertebral, and thoracoscopy.

The thoracoscopic approach was devised as a way to avoid the morbidity associated with a thoracotomy. Presently, VATS sympathectomy is the most commonly performed technique and is considered to be safe and effective [23–26]. Most commonly using this technique, ganglionectomy is performed with removal of ganglia T2 toT3 for palmar hyperhidrosis, and T2 to T4 for axillary hyperhidrosis.

The major complications for thoracic sympathectomy are compensatory hyperhidrosis in 50% to 97% of patients [9–13], gustatory sweating in 32% to 49% [6, 9, 14], phantom sweating in 4% to 48% [1, 27, 28], and Horner's syndrome in 1% to 2.4% [5, 9, 14]. Compensatory hyperhidrosis can result in a dramatically diminished quality of life to such an extent that even with relief of hyperhidrosis, many patients regret undergoing the operation [25, 29–36].

Although the most commonly performed procedure entails the removal of the sympathetic ganglia, some authors have advocated selective division of the sympathetic postganglionic fibers (ramicotomy) that supply the eccrine glands of the upper extremity [15, 19]. Using this technique, Friedel and colleagues [5] reported a success rate of 85% to 95% for palmar hyperhidrosis, 60% to 80% for axillary hyperhidrosis, and a compensatory hyperhidrosis rate of 2.5%. These authors suggested that the sympathetic chain is composed of ganglia as well as postganglionic fibers that travel up and down the chain. Division of the chain and ganglionectomy therefore can disrupt the postganglionic sympathetic fibers that innervate portions of the body other than the upper extremity (Fig 3). Division of the postganglionic sympathetic fibers traveling with intercostals 2, 3, and 4 represents a more specific sympathectomy directed at the upper extremity.

Extensive anatomic dissection of the sympathetic chain has shown white rami communicantes, which synapse with the secondary ganglion within the sympathetic chain, carry signals from the primary ganglion located in the intermediolateral nucleus of the spinal cord [37]. Gray rami communicantes exit the sympathetic ganglion, join the thoracic nerve, and then enter the brachial plexus and travel to the eccrine glands in the skin. In addition, communicating rami connect the intercostal nerves. Ascending communicating rami travel from the sympathetic ganglia to the intercostal nerve located superiorly. Descending communicating rami travel from the sympathetic ganglia to the intercostal nerve located inferiorly. The furthest lateral extent of the communicating rami from the sympathetic chain has been reported to be 29.1 mm [37]. Theoretically, division of the gray rami and the communicating rami 3 cm lateral to the sympathetic chain should result in successful resolution of upper extremity hyperhidrosis with a low incidence of compensatory hyperhidrosis [37].

Selective division of the postganglionic sympathetic fibers is difficult using conventional videoendoscopic techniques. The difficulty arises from 2-dimensional visualization and the limited maneuverability of the conventional videoendoscopic instruments. Previous studies

of selective sympathectomy (ramicotomy) using VATS have shown variable results, with many reporting a high incidence of compensatory hyperhidrosis of 67% to 95% [38–40]. The less-than-optimal results may have been due to the shortcomings of the conventional videoendoscopic technique and resultant poor visualization of the anatomy of the sympathetic chain and the communicating fibers. Robotics provides high-definition 3-dimensional magnified visualization of the surgical field. Because of these properties, robotic instruments facilitate complex maneuvers in a confined space. We reason that these properties of robotics may facilitate selective postganglionic sympathectomy.

In this case series, selective postganglionic sympathectomy was performed with few complications and no deaths. Of the 55 patients, 53 (96%) experienced initial postoperative reduction in hyperhidrosis, which was sustained at a median follow-up of 24 months. Success rates were greater in patients with isolated palmar and combined axillary and palmar hyperhidrosis. There were 2 of 7 patients (28.6%) with isolated axillary hyperhidrosis who did not experience relief of symptoms. It is possible that in these 2 patients communicating rami were present more laterally than the extent of dissection. Given that anatomic dissections have shown communicating rami as far as 29.1 mm from the sympathetic chain [37], extension of the ramicotomy to 4 cm from the chain may result in greater success for the relief of hyperhidrosis.

Transient unilateral Horner's syndrome was seen in 1 patient. Transient unilateral ptosis was seen in 1 patient. Anatomic dissections of the stellate ganglion [37] have shown that in 26% of cadaveric dissections, the stellate ganglion is located at the upper border of the second rib. Transient thermal injury from the dissection over the second rib may explain the incidence of transient Horner syndrome and unilateral ptosis in this series.

Compensatory hyperhidrosis was seen in only 4 of 55 patients (7%). Interestingly, 3 of these 4 patients (75%) had palmar hyperhidrosis. The lower rate of compensatory hyperhidrosis in patients who underwent postganglionic sympathectomy is clarified by examination of the anatomy of the sympathetic chain. Enlarged areas of the chain that are visualized on gross inspection and commonly referred to as ganglia are in fact composed partially of ganglia and partially of rami interganglionares connecting the various ganglia within the sympathetic chain. In addition, the spinal segments supply not only the corresponding ganglion but also other ganglia several segments above and below the corresponding spinal level (Fig 3). Therefore, removal of these enlarged areas, which is commonly referred to as ganglionectomy, not only removes the ganglia corresponding to the spinal level but also disrupts communication within the sympathetic chain. It is hypothesized that it is this disruption that results in high compensatory hyperhidrosis with the technique of ganglionectomy.

The postganglionic efferent nerves (rami communicantes grisei), which innervate the eccrine glands of the upper extremity, emanate from the sympathetic chain and follow intercostal nerves 2, 3, and 4. Therefore, selective division of these postganglionic fibers results in denervation of the eccrine glands without affecting postganglionic fibers to other segments. A more selective denervation of upper extremity eccrine glands is thought to result in decreased rates of compensatory hyperhidrosis.

Limitations of this study include short follow-up and small number of patients. Undoubtedly, the use of robotic technology adds more ports, results in greater morbidity, longer operative times, and greater cost. Theoretically, these shortcomings may be offset by greater accuracy of dissection and the lower rates of compensatory hyperhidrosis. A cost-analysis of the robotic procedure was not performed and will be a subject of further study in the future. The claims in this report are based on prospectively accrued, retrospectively analyzed data. A randomized, prospective trial comparing this approach with other conventional approaches needs to be performed to further validate our results.

References

1. Amin KA. Primary focal hyperhidrosis. DermatologyReview.com Journal. Feb 2007. http://www.dermatologyreview.org/journal/hyperhidrosis.pdf.
2. Fiorellia A, D'Aponteb A, Canonicob R, et al. T2-T3 sympathectomy versus sympathicotomy for essential palmar hyperhidrosis: comparison of effects on cardio-respiratory function. Eur J Cardiothorac Surg 2012;42:454–61.
3. Cerfolio RJ, De Campos JR, Bryant AS, et al. The Society of Thoracic Surgeons expert consensus for the surgical treatment of hyperhidrosis. Ann Thorac Surg 2011;91:1642–8.
4. González P, Serdà J, Rodríguez S, et al. Long-term pulmonary function after thoracic sympathectomy. J Thorac Cardiovasc Surg 2005;129:1379–82.
5. Friedel G, Linder A, Toomes H. Sympathectomy and vagotomy. In: Manncke K, Rosin RD, eds. Minimal access thoracic surgery. First edition. Philadelphia: Lippincott-Raven Publishing; 1998:67–83.
6. Bachmann K, Standl N, Kaifi J, et al. Thoracoscopic sympathectomy for palmar and axillary hyperhidrosis: four-year outcome and quality of life after bilateral 5-mm dual port approach. Surg Endosc 2009;23:1587–93.
7. Moya J, Ramos R, Morera R, et al. Thoracic sympathicolysis for primary hyperhidrosis: a review of 918 procedures. Surg Endosc 2006;20:598–602.
8. Smidfelt K, Drott C. Late results of endoscopic thoracic sympathectomy for hyperhidrosis and facial blushing. Br J Surg 2011;98:1719–24.
9. Gharagozloo F, Margolis M, Najam F, Tempesta B. Robotic highly selective dorsal thoracic sympathectomy. In: Gharagozloo F, Najam F, eds. Robotic surgery. First edition. New York: McGraw Hill; 2008:211–8.
10. Riet M, Smet AA, Kuiken H, et al. Prevention of compensatory hyperhidrosis after thoracoscopic sympathectomy for hyperhydrosis. Surg Endosc 2001;15:1159–62.
11. Neumayer C, Zacherl J, Holak G, et al. Limited endoscopes thoracic sympathetic block for hyperhydrosis of the upper limb: reduction of compensatory sweating by clipping T4. Surg Endosc 2004;18:152–6.
12. Lin TS. Endoscopic clipping in video-assisted sympathetic blockade for axillary hyperhydrosis. An analysis of 26 cases. Surg Endosc 2001;15:126–8.
13. Lin CC, Telaranta T. Lin-Telaranta classification: the importance of different procedures for different indications in sympathetic surgery. Ann Chir Gynaecol 2001;90:161–6.

14. Furlan AD, Mailis A, Papagapiou M. Are we paying a high price for surgical sympathectomy? A systematic literature review of late complications. J Pain 2000;1:245–57.
15. Friedel G, Linder A, Toomes H. Selective video-assisted thoracoscopic sympathectomy. Thorac Cardiovasc Surg 1993;41:245–8.
16. Friedel G, Linder A, Toomes H. Video-assisted thermometrically controlled thoracoscopic sympathectomy. Gen Thorac Surg 1993;1:49–53.
17. Kux E. Thorakoskopishe Eingriffe am Nervensystem. Stuttgart: Thieme Verlag; 1954.
18. Wittmoser R. Die thorakoskopische Operation des rechten unteren Brustsympathikus. Med Bilddienst (BD) 1954;6:79.
19. Lee DY, Kim DH, Paik HC. Selective division of T3 rami comunicantes (T3 ramicotomy) in the treatment of palmar hyperhidrosis. Ann Thorac Surg 2004;78:1052–5.
20. Coveliers H, Meyer M, Gharagozloo F, Wisselink W. Selective sympathectomy for hyperhidrosis: technique of robotic transthoracic selective postganglionic efferent sympathectomy. Eur J Cardiothorac Surg 2012;0:1–3.
21. Kotzareff A. Resection partielle du tronc sympathique cervical droit pour hyperhidrose unilaterale. Rev Med Suisse Rom 1920;40:111–3.
22. Hughes J. Endothoracic sympathectomy. Proc Roy Soc Med 1942;35:585–6.
23. Miller DL, Force SD. Outpatient microthoracoscopic sympathectomy for palmar hyperhidrosis. Ann Thorac Surg 2007;83:1850–5.
24. Doolabh N, Horswella S, Williams M, et al. Thoracoscopic sympathectomy for hyperhidrosis: indications and results. Ann Thorac Surg 2004;77:410–4.
25. Rex LO, Drott C, Claes G, et al. The Boras experience of endoscopic thoracic sympathicotomy for palmar, axillary, facial hyperhidrosis and facial blushing. Eur J Surg Suppl 1998;23–6.
26. Kux M. Thoracic endoscopic sympathectomy in palmar and axillary hyperhidrosis. Arch Surg 1978;113:264–6.
27. Kestenholz PB, Weder W. Thoracic sympathectomy. Curr Probl Dermatol 2002;30:64–76.
28. Orteu CH, McGregor JM, Almeyda JR, et al. Recurrence of hyperhidrosis after endoscopic transthoracic sympathectomy—case report and review of the literature. Clin Exp Dermatol 1995;20:230–3.
29. Baumgartner FJ. Surgical approaches and techniques in the management of severe hyperhidrosis. Thorac Surg Clin 2008;18:167–81.
30. de Campos JRM, Kauffman P, Werebe Ede C, et al. Quality of life, before and after thoracic sympathectomy: report on 378 operated patients. Ann Thorac Surg 2003;76:886–91.
31. Dewey TM, Herbert MA, Hill SL, et al. One-year follow-up after thoracoscopic sympathectomy for hyperhidrosis: outcomes and consequences. Ann Thorac Surg 2006;81:1227–32.
32. Dumont P, Denoyer A, Robin P. Long-term results of thoracoscopic sympathectomy for hyperhidrosis. Ann Thorac Surg 2004;78:1801–7.
33. Gossot D, Kabiri H, Caliandro R, et al. Early complications of thoracic endoscopic sympathectomy: a prospective study of 940 procedures. Ann Thorac Surg 2001;71:1116–9.
34. Licht PB, Pilegaard HK. Severity of compensatory sweating after thoracoscopic sympathectomy. Ann Thorac Surg 2004;78:427–31.
35. Schmidt J, Bechara FG, Altmeyer P, et al. Endoscopic thoracic sympathectomy for severe hyperhidrosis: impact of restrictive denervation on compensatory sweating. Ann Thorac Surg 2006;81:1048–55.
36. Gossot D, Galetta D, Pascal A, et al. Long-term results of endoscopic thoracic sympathectomy for upper limb hyperhidrosis. Ann Thorac Surg 2003;75:1075–9.
37. Zhang B, Li Z, Yang X, Li G, Wang Y, Cheng J, Tang X, Wang F. Anatomical variations of the upper thoracic sympathetic chain. Clin Anat 2009;22:595–600.
38. Gossot D, Toledo L, Fritsch S, Celerier M. Thoracoscopic sympathectomy for upper limb hyperhidrosis: looking for the right operation. Ann Thorac Surg 1997;64:975–8.
39. Kim DY, Paik HC, Lee DY. Comparative analysis of T2 selective division of rami-communicantes (ramicotomy) with T2 sympathetic clipping in the treatment of craniofacial hyperhidrosis. Eur J Cardiothorac Surg 2004;26:396–400.
40. Lee DY, Paik HC, Kim DH, Kim HW. Comparative analysis of T3 selective division of rami communicantes (ramicotomy) to T3 sympathetic clipping in treatment of palmar hyperhidrosis. Clin Auton Res 2003;13 (Suppl 1):I45–7.

INVITED COMMENTARY

In general, few operations have caused more disagreement and conflicting opinions than sympathetic procedures for primary hyperhidrosis. Hundreds of retrospective case series have been published, case-control studies are numerous, and randomized trials are only slowly emerging. There is little consensus regarding which level of the sympathetic chain should be targeted and what extent of sympathectomy should be performed, just as it is controversial which surgical technique is better. Some surgeons prefer to transect the sympathetic chain; others resect it or ablate the ganglion. Some use cautery, others use the harmonic scalpel, and some believe that the application of metal clips is preferable because of a theoretic possibility of reversing the procedure if the patients experience intolerable side effects.

Side effects are very common, in particular compensatory sweating, which is believed to be a thermoregulatory response. Given the theoretic advantage of reducing compensatory sweating by limiting the extent of sympathectomy, a "selective sympathectomy" was suggested wherein only the rami communicantes from the sympathetic trunk to the upper extremity are divided without targeting the trunk itself. This procedure is also called ramicotomy and has been used for more than 20 years, but there are only a few published results. Most surgeons have abandoned the technique because earlier studies found a significantly higher recurrence rate in comparison with sympathectomy. Also, what first seemed to be an operation that almost eliminated compensatory sweating [1] was not confirmed in subsequent studies wherein compensatory sweating was reported in 62% to 73% of patients [2–5], which is comparable with the results of conventional sympathectomy.

In the present case series, the authors [6] treated 55 patients with primary hyperhidrosis by ramicotomy over a 5-year period, using robotic technology rather than simple video-assisted thoracic surgery (VATS). The effect on palmar hyperhidrosis was excellent and comparable with traditional sympathectomy, inasmuch as 96% of patients had sustained relief of their hyperhidrosis after 2 years—the time interval when most of the recurrences after ramicotomy occurred in previous reports. More importantly, the authors found a remarkably low incidence of compensatory sweating in just 7% of their

0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2012.08.021