Surgical sympathectomy for reflex sympathetic dystrophy syndromes

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Purpose: The purpose of this study was the assessment of the efficacy of thoracoscopic cervicodorsal and open lumbar sympathectomy for the reduction of pain severity and disability associated with reflex sympathetic dystrophy (RSD).
Methods: From 1992 to 2000, 73 patients with RSD underwent 46 video-assisted thoracoscopic (first to fourth thoracic ganglion) or 37 surgical lumbar (first to fourth lumbar ganglion) sympathetic chain resections. The patients were referred from multidisciplinary pain clinics with documented sympathetically maintained pain syndrome on the basis of reproducible more than 50% reduction in pain severity score (0, no pain; 10, most severe pain imaginable) for more than 2 days after sympathetic block therapy. The mean duration of the RSD symptoms before sympathectomy was 26 ± 14 months (range, 6 to 100 months). Postoperative pain severity score, limb disability, and overall patient satisfaction were assessed by an independent third-party observer at a mean follow-up period of 30 months.
Results: No operative mortality or serious morbidity (Horner's syndrome, bleeding that needed transfusion, wound infection) occurred. Transient (<3-month) postprocedural sympathalgia developed in one third of the patients for cervicodorsal sympathectomy and 20% of the patients for lumbar sympathectomy and was treated effectively with trigger point/proximal ganglion block therapy or transcutaneous electrical nerve stimulation. At 3 months after sympathectomy, 10% of the patients had conditions that were judged treatment failures with no reduction in pain severity or limb disability. The remaining patients testified to more than 50% pain reduction, with pain severity scores decreasing from a mean of 8.7 before surgery to 3.4 after sympathectomy. At 1 year, one quarter of the patients had continued significant pain relief (pain severity score, <3) and an additional 50% of the patients indicated continued but reduced pain severity and an increase in daily/work activities. Overall, patient satisfaction (willingness to have procedure again, benefit from sympathectomy) was 77% and was not significantly influenced by patient age, RSD duration/stage, or extremity involvement (lumbar, 84%; cervicodorsal, 72%).
Conclusion: Patients with RSD with a confirmed sympathetically maintained pain syndrome can realize long-term benefit from surgical sympathectomy. Procedural efficacy was similar for both upper limb and lower limb RSD syndromes, although the level of pain reduction did deteriorate with time. After sympathectomy, the patients with RSD had a low incidence rate (7%) of "new" complex regional pain or disabling compensatory sweating syndromes. (J Vasc Surg 2002;35:269-77.)

Surgical sympathectomy for the treatment of disabling posttraumatic pain syndromes was introduced more than 70 years ago.[1] The entity of burning pain, sympathetic hyperactivity, hyperesthesia, joint stiffness, muscle atrophy, and skin changes after nerve, bone, or soft tissue injury has been described with a variety of terms, including causalgia, Sudeck's atrophy, reflex sympathetic dystrophy (RSD) syndrome, and in 1995 complex regional pain syndrome (CRPS), by the International Association for the Study of Pain.[2,3] The best way to describe RSD is in terms of an extremity injury caused by trauma, infection, surgery, or repetitive motion disorder (ie, carpal tunnel syndrome) that does not follow the normal healing path. The pathophysiology is unknown, development does not appear to depend on the magnitude of injury, and diagnosis may be hampered by a lack of objective findings or legal issues (accusations of malingering for the collection of disability benefits). The hallmark of RSD is a burning extremity pain and mobility problems out of proportion to those expected from the injury, but other clinical manifestations can develop, such as skin changes, vasospasm, swelling, movement disorder, muscle atrophy, or the spreading of RSD symptoms to the trunk or in a mirror-image pattern.

Although education is the most important method for the treatment of RSD, the typical pain clinic treatment protocol includes psychosocial counseling (pain coping skills, drug abuse potential, relaxation techniques, family support assessment), sequential drug (oral, transdermal) trials for the optimization of pain control, physical/occupational therapy, and a series of three to six local anesthetic (bupivacaine hydrochloride) sympathetic blocks. With the selective blocking of the sympathetic nervous system, both the patient and the physician gain useful diagnostic information as to whether the pain is sympathetically maintained and potentially responsive to sympathectomy and

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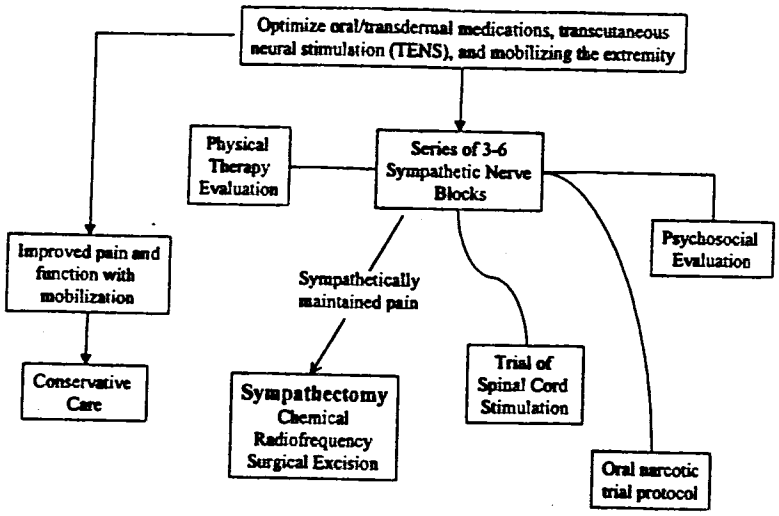

Typical pain clinic treatment protocol for reflex sympathetic dystrophy or complex regional pain syndrome designed to rehabilitate patient in shortest possible time and initiate safest and most cost-effective therapies first.

whether sympathectomy, in some patients, may provide a permanent cure or remission. Only patients with a significant decrease in pain after the sympathetic block therapy (ie, sympathetically maintained pain [SMP]) should be considered candidates for sympathectomy.[4-8] Because surgical sympathectomy is an invasive procedure with potential complications, it should be reserved for patients with SMP and a persistent RSD disability that is not responsive to other treatment methods, including chemical sympathectomy.

In the past decade, minimally invasive endoscopic approaches to sympathetic chain excision have replaced open surgical procedures, especially for cervicodorsal sympathectomy.[9,10] In this clinical review, the outcome of video-assisted thoracoscopic sympathectomy was compared with open lumbar sympathectomy for patients referred from a multidisciplinary pain clinic with an SMP-RSD pain syndrome. The goal of this retrospective review was the documentation of the efficacy, the duration of pain reduction, and the adverse sequelae of the sympathectomy for upper limb and lower limb RSD syndromes, including the development of new CRPSs during a mean follow-up interval of 30 months.

METHODS

Patient population. From 1992 to 2000, 73 patients who were referred from regional multidisciplinary pain clinics with RSD for consideration of surgical (cervicodorsal, n = 46; lumbar, n = 37) sympathectomy were judged to be appropriate candidates. The 56 female and 17 male patients ranged in age from 13 to 66 years (mean, 35 ± 10 years). All the patients had clinical features of RSD (Appendix) with positive thermographic results that indicated a cold extremity and were enrolled in a pain clinic treatment program (Fig). At the time of referral, the patients were significantly impaired or disabled because they were unable to perform normal daily activities or attend school or because they had experienced loss of employment because of pain and limb mobility problems. Although the staging of RSD is a dying concept, in part because of the unpredictable course of the disease, two thirds of the patients who consented to undergo sympathectomy had stage I/II symptoms and signs and one third had stage III disease. The patient-provided pain severity scores (0, no pain; 5, pain interferes with daily/work activities; 10, worst pain imaginable; recorded on a visual analogue scale) were similar in the stage I/II (8.4 ± 1.1) and stage III (8.7 ± 1.2) patient groups. In general, an RSD pain score in excess of 8 indicated severe, intractable pain and limb disability, precluding employment. The clinical characteristics of the patients who underwent either thoracoscopic dorsal or open lumbar sympathectomy are listed in Table I. The age, gender, duration of RSD symptoms before intervention, and clinical disease stage were similar in the patients selected for either cervicodorsal or lumbar sympathectomy. Fifteen patients (20%) had bilateral symptoms of RSD at the time of initial surgical sympathectomy. The duration of RSD symptoms ranged from 6 to 100 months, with a similar RSD onset-to-sympathectomy time interval in the cervicodorsal (25 ± 20 months) and lumbar (26 ± 15 months) sympathectomy groups.

An episode of trauma to the limb was the most common cause of RSD (71% of patients). The mechanisms of trauma varied and included the following episodes (in descending order of frequency): motor vehicle accident, fracture, joint sprain, crush injury, electrical injury, and stab wound. Other causes for RSD were prior surgical procedures (carpal tunnel release, n = 4; hand surgery, n = 1; ankle surgery, n = 4; varicose vein stripping, n = 1), intravenous drug infiltration in the hand/forearm in three patients, and lower limb superficial thrombophlebitis in

Table I. Gender, age, duration of reflex sympathetic dystrophy symptoms, and clinical stage of 73 patients who underwent thoracoscopic cervicodorsal or open lumbar sympathectomy

	Type of sympathectomy		
	Cervicodorsal (n = 46)	*Lumbar (n = 37)*	*Total (n = 83)*
No. of patients	41	32	73
Female patients	30	26	56 (77%)
Male patients	11	6	17 (23%)
Age (years)	35 ± 10.2	36 ± 9.7	
Age range (years)	(13-66)	(14-65)	
Patients with bilateral RSD	7 (17%)	8 (25%)	15 (20%)
Cause			
Trauma	33	26	5 (71%)
Prior surgical procedure	7	8	15 (18%)
IV infiltration	3	0	3 (4%)
Superficial phlebitis	0	1	1 (1%)
Spreading RSD	3	2	5 (6%)
Duration of RSD symptoms (months)	25 ± 20	26 ± 15	
RSD stage at time of sympathectomy*			
Stage I	1	1	2 (2%)
Stage II	33	21	54 (65%)
Stage III	11	16	27 (33%)

*See Appendix.
RSD, Reflex sympathetic dystrophy; *IV*, intravenous.

one patient. Five patients had spreading RSD develop and were seen with multiple extremity involvement. Two patients sustained another episode of trauma during the follow-up period, had disabling SMP-RSD develop in a lower extremity, and underwent lumbar sympathectomy.

All the patients had undergone a recent (<3 months) series of three to six sympathetic chain blocks with 0.25% bupivacaine hydrochloride that confirmed SMP syndrome. For a patient to be considered a candidate for sympathectomy, a reproducible SMP response to the ganglion block therapy was necessary. The criterion for a positive response was a greater than 50% reduction in the patient's basal pain severity score, on the basis of a visual-analogue scale from 0 (no pain) to 10 (the worst pain imaginable). The reduction in pain severity had to persist for at least 2 days and be accompanied by improved muscle strength or limb mobility. Also, a positive response to sympathetic block therapy had to occur with most of the blocks for the patient to be considered a surgical candidate. The number of sympathetic blocks before sympathectomy ranged from six to more than 40. Several patients had undergone monthly sympathetic block therapy for more than 1 year before surgical sympathectomy. Nine patients had undergone prior invasive procedures for pain reduction that included the following procedures: chemical lumbar sympathectomy (n = 7) or radiofrequency ablation of the stellate ganglion (n = 2). During this time interval, the referring pain clinic specialists estimated that less than one third of the patients undergoing treatment for RSD were referred to the vascular center for consideration of surgical sympathectomy.

Techniques of surgical sympathectomy. All the procedures were performed with general anesthesia with the patients admitted the day of surgery. The thoracoscopic technique outline by Ahn et al[9] was used to excise the dorsal sympathectomy chain from below the stellate ganglion to the third or fourth thoracic ganglion. The patients were positioned in the lateral decubitus position, with the arm elevated and the table flexed to widen the intercostals spaces for port insertion. A camera port for a 0 degree–angle thoracoscope was introduced in the sixth intercostal space at the midaxillary line followed by the introduction of the two to three remaining ports in direct vision. Adhesions of the lung to the pleural apex were incised, when necessary, and the sympathetic chain was visualized at the costovertebral junction. Carbon dioxide insufflation (low flow, 8-cm H_2O pressure) was used to aid in lung deflation and retraction. Pleural overlying the sympathetic chain was grasped and incised with electrocautery set at the lowest possible level for hemostasis and tissue cutting. With a hook dissector, the sympathetic chain was elevated and dissected with scissors and electrocautery and the rami of the ganglion was cut. Dissection began below the stellate ganglion with the placement of a clip across the inferior aspect of the ganglion, and excision of the sympathetic proceeded caudal to the third or fourth thoracic ganglion. An intercostal nerve block with 0.25% bupivacaine hydrochloride was performed and followed by the insertion of a 28F chest tube with direct vision. The incisions were closed with absorbable suture. A chest x-ray was obtained in the postoperative recovery unit for the verification of lung expansion. The average procedure time was approximately 50 minutes.

Lumbar sympathectomy was performed via a transverse incision positioned lateral to the rectus muscle sheath and midway between the costal margin and iliac crest. After the injection of the incision site with 0.25% bupivacaine hydrochloride, skin and external oblique mus-

cle and fascia were incised. A muscle splitting incision of the internal and transverse abdominal muscles was performed to enter the retroperitoneum. Peritoneum was retracted medially, and the psoas muscle and genitalfemoral nerve were visualized. The sympathetic chain then was palpated on the vertebral column, followed by the dissection of the chain and ganglion with direct vision. Ganglions and sympathetic chain from the diaphragm hiatus (first lumbar ganglion) to the pelvic brim (fourth lumbar ganglion) were excised. After inspection for hemostasis, the abdominal incision was closed with absorbable suture. The average procedure time was approximately 45 minutes.

Patient care after sympathectomy. For the first 24 to 48 hours after sympathectomy, surgical incision pain and RSD pain were controlled with a patient-activated intravenous morphine infusion pump with a basal infusion rate. The patients were typically discharged on the 2nd or 3rd postoperative day after thoracoscopic sympathectomy and on the 3rd to 4th postoperative day after open lumbar sympathectomy. Discharge pain medications were similar to the admission regime and were supplemented with oral doses of hydrocodone (5 to 7.5 mg) and acetaminophen (325 to 500 mg) every 4 to 6 hours as necessary. The patients underwent evaluation at 1 week, 4 weeks, and 3 months in the vascular surgery clinic and, subsequently, in the referring pain clinic. After thoracoscopic dorsal sympathectomy, persistent chest wall, "new" posterior scapula/shoulder pain was treated in the pain clinic with trigger point injection of local anesthetics, repeat stellate ganglion block therapy, or transcutaneous electrical nerve stimulation (TENS).

Analysis of patient outcomes. Pain reduction, limb disability, and patient satisfaction after the sympathectomy procedure were assessed in two ways: review of outpatient surgery and pain clinic records and administration of a questionnaire by an independent observer not involved in the patient's care or prior procedure. The outcomes analyzed were chosen for consistency with the literature on RSD pain reduction with other management options (chemical sympathectomy, spinal cord stimulation, morphine pump). During the clinical follow-up period, the following outcomes were analyzed: pain severity score reduction after sympathectomy at 3-month and 12-month intervals; frequency of more than 50% pain reduction at last follow-up examination; disability status at last follow-up examination, combined with patient satisfaction with treatment (ie, "Considering the hospitalization, discomfort, and expense of surgical sympathectomy, would you undergo the procedure again for the same result?"); and additional procedures for pain control. The following patient and treatment characteristics were considered independent variables in the statistical analysis: clinical stage of RSD (I/II versus III), RSD cause, duration of RSD before intervention (<18 months versus >18 months), patient age (≤35 years versus >35 years), and type of procedure (thoracoscopic versus open lumbar sympathectomy). The incidence rates of "new" CRPS syndromes and sequelae of sympathectomy were also tabulated relative to the type of sympathectomy procedure or multiple procedures. Seven patients (10%) were lost to follow-up examination after 1 year. The patient follow-up period ranged from 8 to 86 months (mean, 30 months).

Statistical analysis. Student t test (paired and unpaired) was used for the comparison of continuous variable data (duration of RSD, pain severity score) for procedure outcome categories. χ^2 test was used for the comparison of categoric data (patient satisfaction). The continuous data (age, time, pain severity score) were recorded as mean ± standard deviation.

RESULTS

No operative mortality or serious morbidity (Horner's syndrome, bleeding that needed transfusion, chylothorax, wound infection) occurred after surgical sympathectomy. One patient had chest tube bleeding develop after thoracoscopic dorsal sympathectomy and was returned to the operative room for electrocautery of bleeding from the excised thoracic sympathetic chain site. After sympathectomy, all the patients showed clinical signs of regional sympathetic denervation with a warm dry extremity and reported significant reduction in RSD pain. In both upper and lower extremities, hand/finger or ankle mobility was improved. The length of stay after dorsal sympathectomy ranged from 2 to 7 days (mean, 3.1 days), with patients who underwent open lumbar sympathectomy staying, on the average, 1 day longer. Four patients needed readmission 1 to 2 days after discharge for control of chest wall/incisional pain after thoracoscopic dorsal sympathectomy.

Postprocedural sympathalgia (ie, postsympathectomy neuralgia) developed in a significant number of patients after both thoracoscopic dorsal (11 of 46 procedures; 24%) and lumbar (seven of 37 procedures; 19%) sympathectomy. The patients typically had a "new," constant deep pain 1 to 2 weeks after operation either in the posterior upper back over the scapula after dorsal sympathectomy or in the anterolateral thigh after lumbar sympathectomy. These postsympathectomy pain syndromes were effectively treated with narcotics, with antiinflammatory drugs, and, in the patients for dorsal sympathectomy, with trigger point/proximal ganglion block therapy or TENS. All but one patient reported resolution of pain/discomfort by 2 to 3 months. Although most women indicated breast pain or paresthesias for 4 to 6 weeks after thoracoscopic dorsal sympathectomy, in only one woman was the breast sensitivity persistent and bothersome.

Patient rating scores of presympathectomy RSD pain severity were similar in patients who underwent dorsal (8.5 ± 1.2) or lumbar (8.4 ± 1.6) sympathectomy. After discharge, essentially all the patients indicated RSD pain reduction and more comfortable warm feelings in the sympathectomized limbs. By 2 to 3 months after sympathectomy, seven patients (10%; cervicodorsal, n = 5; lumbar, n = 2) had conditions that were judged treatment

Table II. Pain severity scores* (mean ± standard deviation) of 73 patients with sympathetically maintained reflex sympathetic dystrophy who underwent treatment with thoracoscopic cervicodorsal (n = 46) or open lumbar sympathectomy (n = 37)

	Pain severity score provided by patient			
			After sympathectomy	
Type of sympathectomy	*Basal RSD pain*	*After stellate ganglion block*	*At 3 months*	*At 1 year*
Cervicodorsal	8.5 ± 1.2	3.5 ± 1.4	3.2 ± 1.5	4.3 ± 2.5†
Lumbar	8.4 ± 1.6	3.5 ± 1.6	3.1 ± 1.0	3.6 ± 1.1†

	After sympathectomy	
Outcomes relative to patient variable	*At 3 months*	*At 1 year*
Time from injury to sympathectomy (<18 months)		
Lumbar (n = 15)	3.0 ± 1	3.3 ± 1.7
Cervicodorsal (n = 26)	3.4 ± 1.3	3.9 ± 2†
Time from injury to sympathectomy (>18 months)		
Lumbar (n = 22)	3.1 ± 1	3.7 ± 2.1
Cervicodorsal (n = 20)	3.2 ± 1.9	4.7 ± 3†
Patient age ≤ 35 years		
Lumbar (n = 21)	3.2 ± 1.1	4.0 ± 2.1†
Cervicodorsal (n = 22)	3.1 ± 1.7	3.9 ± 2.5†
Patient age > 35 years		
Lumbar (n = 16)	2.9 ± 0.7	3.0 ± 1.2
Cervicodorsal (n = 24)	3.5 ± 1.4	4.7 ± 2.4†
Stage I/II of RSD syndrome		
Lumbar (n = 21)	3.1 ± 1.1	3.4 ± 1.9
Cervicodorsal (n = 34)	3.1 ± 1.4	3.7 ± 2.1
Stage III of RSD syndrome		
Lumbar (n = 16)	3.0 ± 1.0	3.7 ± 2†
Cervicodorsal (n = 11)	3.9 ± 1.5	5.5 ± 2.8‡

*Intensity of pain scale (no pain, 0; worst pain imaginable, 10).
†$P < .05$ compared with 3-month pain severity score.
‡$P = .01$† compared with reflex sympathetic dystrophy stage I/II.
RSD, Reflex sympathetic dystrophy.

failures with no reduction in pain severity or limb disability. The absence of RSD pain reduction was apparent by 1 month in most of these patients, but because of residual incision pain or the development of postsympathectomy neuralgia, assessment of benefit from sympathectomy was not possible. All the remaining patients testified to more than 50% pain reduction at 3 months and improved limb mobility. Comparative reduction of pain severity scores ($P > .1$) was achieved after either cervicodorsal or lumbar sympathectomy, with individual patient scores ranging from 0 to 9 (Table II). The mean pain severity scores at 3 months after dorsal (3.3 ± 1.5) and lumbar (3.1 ± 1.5) sympathectomy were similar ($P > .05$) and comparable with the patient rating of pain reduction after sympathetic block (3.5 ± 1.6 and 3.1 ± 1.5, respectively).

The pain severity scores increased in both patient treatment groups by 1 year after sympathectomy. An additional eight patients after dorsal sympathectomy and four patients after lumbar sympathectomy indicated increased RSD pain and limb disability beyond 3 months. Overall, at 1 year after sympathectomy or at last follow-up examination, a pain severity score of more than 5 and persistent RSD limb disability indicated no benefit after 13 of 46 thoracoscopic dorsal (28%) and six of 37 lumbar (16%) sympathectomy procedures. The pain severity scores increased significantly in both the dorsal sympathectomy patient group ($P < .001$; from 3.3 at 3 months to 4.0 at last follow-up examination) and the lumbar sympathectomy patient group ($P = .048$; from 3.1 ± 1 at 3 months to 3.6 ± 1 at last follow-up examination).

Long-term patient satisfaction (lower pain severity score, increased limb mobility, patient would undergo procedure again) was not influenced by the RSD stage, duration of RSD before surgical sympathectomy, or patient age (Tables II and III). The patient-provided pain severity scores at 3 months and 1 year were similar ($P > .05$) in each sympathectomy group, regardless of RSD duration or patient age. The overall patient satisfaction with the procedure was 71% (33 of 46 procedures) after thoracoscopic dorsal sympathectomy and 84% (31 of 37 procedures) after open lumbar sympathectomy. A pain severity score of less than 3, which indicated minimal pain and limb disability, was recorded by the patient after 11 of 46 dorsal sympathectomy procedures (24%) and after nine of 37 lumbar sympathectomy procedures (24%). An additional 50% of the patients indicated benefit from sympa-

Table III. Patient satisfaction with sympathectomy relative to type of procedure and reflex sympathetic dystrophy stage

	No. of procedures	Patient would undergo procedure again
Type of sympathectomy		
Thoracoscopic dorsal	46	33* (72%)
Open lumbar	37	31† (84%)
Total	83	64 (77%)
Stage of RSD syndrome		
Stage I or II	56	44 (78%)
Stage III	27	20 (74%)

*Pain severity score, 3 ± 2.
†Pain severity score, 3 ± 1.1.
RSD, Reflex sympathetic dystrophy.

thectomy, but the degree of initial RSD pain reduction lessened with time. Despite an increase in pain, these patients reported that their ability to participate in physical/occupational therapy and subsequently perform daily/work activities with the limb was improved. The mean pain score of the patients who were satisfied with the procedure was 3 ± 2 after dorsal and 3 ± 1.1 after lumbar sympathectomy. Six of nine patients (67%) with prior chemical/radiofrequency ganglion ablation and persistent RSD indicated benefit from dorsal (n = 2) or lumbar (n = 4) sympathectomy.

The 19 patients with conditions that were early sympathectomy failures or who later had increasing RSD pain scores develop (dorsal, 7.3 ± 1.1; lumbar, 6.5 ± 2.4) underwent treatment with several methods, including spinal cord stimulation (n = 10), morphine pump (n = 7), additional surgical procedures (thoracic outlet decompression, n = 2; orthopedic procedures, n = 2; ulnar nerve release procedure, n = 1), and continued pain clinic treatments (TENS, clonidine hydrochloride patches, sympathetic blocks, biofeedback, drug therapy).

During the mean follow-up period of 30 months, five patients (7%) had a "new" CRPS develop (spreading RSD, n = 3; new episode of trauma leading to RSD, n = 2). No patient underwent amputation for RSD syndrome. Compensatory sweating syndromes that affected the face, back, or other limbs were indicated by three patients after lumbar sympathectomy and by five patients after dorsal sympathectomy (overall incidence rate, 8 of 83 procedures; 10%). All conditions were judged by the patients to be nondisabling. One patient after bilateral dorsal sympathectomy and a prior unilateral chemical lumbar sympathectomy had orthostatic hypotension develop that improved with mineral corticoid administration. One patient with RSD of all limbs who underwent bilateral dorsal and lumbar sympathectomy during a period of 2 years testified to satisfaction from all the procedures and no disabling neurologic, compensatory sweating, or heat intolerance sequelae. Seven of nine patients (78%) who underwent multiple sympathectomy procedures for RSD or spreading RSD indicated benefit from all the procedures. All the patients had benefitted from the initial sympathectomy procedure.

DISCUSSION

The management of RSD syndromes is relevant to vascular surgeons because many patients are initially referred for evaluation of extremity pain, cyanosis, skin temperature changes, and edema—all of which can imitate arterial/venous disease. The vascular examination results are invariably normal in these young, healthy, and commonly female patients, but the limb pain is deemed excruciating and disabling. When compared with the pain associated with cancer, arthritis, or childbirth, RSD pain is commonly rated as one of the most intense imaginable. Although there is a long history of surgical sympathectomy for pain management, evidence-based data that support its application for the disability caused by RSD come primarily from noncontrolled trial results, retrospectively reviewed and analyzed or reported by treating physicians. Most surgical series involve a retrospective analyzed series of patients that indicates the early effectiveness of the procedure with pain reduction in 60% to 90% of patients.[4-9] Adverse effects of sympathectomy, durability of the procedure in terms of pain reduction, or late functional status of patients have not been systematically reported, and thus failures may have been underestimated. These results have led some pain specialists to question the benefit of the surgical sympathectomy.[11]

Our review showed that most patients with a documented sympathetically maintained RSD syndrome did benefit from surgical sympathectomy. Pain reduction and improved function of the involved limb was documented by the treating physicians, by the log of patient-rated severity scores, and by an independent observer not involved in the patient's care who interviewed patients beyond 1 year of the procedure. Only one quarter of the patients indicated no or minimal residual disability or pain (ie, were "cured" with surgical sympathectomy). Most patients testified to sustained, long-term benefit when queried as to whether they would undergo the sympathectomy procedure again. Of note, the outcomes after the more minimally invasive thoracoscopic dorsal sympathectomy were comparable with the outcomes of lumbar sympathectomy performed via a standard open surgical exposure. Patient age, duration of RSD syndrome, and RSD disease stage also did not significantly influence outcomes. Overall, the patient satisfaction and the pain reduction (cervicodorsal, 72%; lumbar, 84%) was comparable with the patient series reported by Olcott et al[6] (91% of patients [n = 35] benefitted after open cervicodorsal or lumbar sympathectomy, including use of extended sympathectomy for nonresponders), by AbuRharma et al[7] (71% satisfactory outcome after open surgical excision; 28 patients), and by Johnson et al[12] (60% pain relief after thoracoscopic sympathectomy; 10 patients).

The incidence rate of postsympathectomy problems was similar after the two types (cervicodorsal and lumbar)

of surgical sympathectomy. Postsympathectomy neuralgia or sympathalgia developed within 1 to 2 weeks in approximately 20% of the patients. The pain was characterized as a spontaneously occurring deep aching pain in the posterior shoulder (after cervicodorsal sympathectomy) or anterolateral thigh (after lumbar sympathectomy). Patients often conclude that this is a "new" RSD syndrome and need to be assured that it is not. The pain can be effectively treated with methods such as trigger point and proximal sympathetic ganglion block therapy or TENS and with narcotics or nonsteriodal antiinflammatory medications. The symptoms typically abated by 3 months after the procedure. Thus, the patients should be informed that sympathectomy may be a two-step procedure: destruction of the sympathetic nerves followed by one or more additional sympathetic/trigger point blocks. The mechanism of postsympathectomy pain is hypothesized to be the result of a complex neuropathic and central deafferentation/reafferentation syndrome caused by transection or paraspinal somatic and visceral afferent axons within the sympathetic chain, subsequent cell death of axotomized afferent neurons, and persistent sensitization of spinal nociceptive neurons by pain conditions present before sympathectomy.[13] Other adverse sequelae of sympathectomy, such as disabling compensatory sweating and chronic neurologic pain, were uncommon in this series. Most patients noted improvements in daily activities such as sleeping, walking, dressing, driving, and sexual activity. However, two thirds of the patients with RSD as a result of work-related trauma have received permanent disability since their injury, and disabilities related to joint contracture or severe muscle atrophy did not improve.

Not all the patients benefitted from surgical sympathectomy. Despite compelling evidence that SMP syndrome was present on the basis of more than 50% pain reduction after multiple sympathetic blocks, 28% of patients after dorsal sympathectomy and 16% of patients after lumbar sympathectomy indicated no prolonged benefit and regretted that they had agreed to undergo the procedure. The incidence rates of sympathectomy failure was similar in patients with stage II (22%) and stage III (26%) RSD syndromes. Pain specialists consider long-term more than 50% reduction in pain severity for greater than one half of patients with RSD as a "good" therapeutic result, and thus, in this respect, surgical sympathectomy can be considered efficacious. Reports of spinal cord stimulation for chronic, intractable pain have shown continued pain relief in approximately 50% of patients.[14,15] It is a disservice to patients with RSD and to the medical profession to promise 90% or greater success rates of pain reduction with invasive procedures. Importantly, there is no test that will accurately identify the "best" candidate for surgical sympathectomy. Patient selection requires documentation of SMP response with sympathetic block, a well-informed and motivated patient, and availability of family and financial support for postsympathectomy rehabilitation and physical therapy. Many patients have concomitant myofascial pain syndromes and will not experience prolonged improvement of symptoms, despite initial amelioration in pain after sympathectomy. Patients in this study whose conditions did not benefit from sympathectomy were recommended to try other methods, including use of a morphine pump and spinal cord stimulation for pain reduction. No patient in this study underwent limb amputation after sympathectomy for persistent RSD syndrome.

The activation of the sympathetic system after injury is important for survival. The autonomic system response causes blood vessels in the skin to contract, forcing blood into muscle and enhancing "fight or flight" ability. Ordinarily, the sympathetic system shuts down within minutes to hours after injury, but in the individuals in whom RSD develops, sympathetic activity remains hyperactive. The mechanism by which injury triggers RSD/CRPS is unclear. Theoretically, the abnormal sympathetic activity at the site of injury may cause an inflammatory response that causes blood vessels to spasm, leading to more swelling and pain. When RSD syndrome is recognized and treated early with patient education, antiinflammatory drugs, sympathectomy blocks, and physical therapy, a permanent cure can be achieved. Untreated, the syndrome can lead to intractable pain and swelling that extends beyond the area of original trauma. Spreading RSD syndrome with diffuse limb pain, muscle wasting, and joint immobility (ie, stage III disease) is more difficult to treat. The goal should be treatment but not overtreatment. Documentation of a sympathetically maintained or independent RSD syndrome provides useful information for treatment options, especially with the identification of those patients who may benefit from sympathectomy or other pain reduction interventions.[15,16] At present, reproducible more than 50% pain reduction and improved limb mobility after sympathetic ganglion block remains the best method for predicting the response to surgical sympathectomy. A failed chemical or radiofrequency sympathectomy should not exclude the patient if SMP-RSD syndrome can be verified.

Neurologic pain and compensatory sweating syndromes were common after both thoracoscopic dorsal and open lumbar sympathectomy, but most conditions resolved within weeks or were nondisabling. In only two patients was the development of a persistent postsympathectomy sympathalgia the reason for patient dissatisfaction with the procedure. Use of the less invasive thoracoscopic technique for dorsal sympathetic chain excision did not decrease the incidence rate of postoperative sympathalgia reported in the literature. The endoscopic technique was well received by the patients and was associated with a shorter hospital stay than was open lumbar sympathectomy procedure. Proper informed consent for surgical sympathectomy should detail the possibility of "no benefit" and the potential for transient neuropathic pain syndromes. Physician and patient review of the clinical practice guidelines developed by the Reflex Sympathetic Dystrophy Syndrome Association of America (www.rsds.org) can assist patients in making informed choices about their treatment. The development of a

"new" CRPS did occur in 7% of the patients, which emphasizes the importance of patient education regarding susceptibility to RSD after trauma and the possibility of spreading RSD. It is essential that patients avoid reinjury during their postoperative physical therapy sessions. Given the incomplete relief of RSD in most patients and the potential for adverse sequelae, only patients with a documented sympathetically maintained RSD syndrome should be considered for surgical sympathectomy. Pain reduction and instruction for the patients with RSD on use of the affected limb through activities of daily living can be improved with sympathectomy.

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Appendix. Staging of reflex sympathetic dystrophy/ complex regional pain syndrome*

Stage I
Onset of severe pain limited to site of injury
Increased sensitivity of skin to touch and light pressure (hyperesthesia)
Localized swelling
Muscle cramps
Stiffness and limited mobility
Skin color/temperature changes from erythema/warm to cyanosis/cold
Increased sweating (hyperhidrosis)
Stage II
Diffuse severe pain not limited to site of injury
Spreading swelling that may change from soft to brawny
Changes in hair (coarse, scant) and nails (growth changes, brittle, grooved)
Early changes of osteoporosis
Muscle atrophy
Stage III
Marked atrophy of muscle and skin
Intractable pain with involvement of entire limb and adjacent trunk
Bilateral or multiple limb involvement

*Adapted from Clinical Practice Guidelines of Reflex Sympathetic Dystrophy Syndrome Association of America (www.rsds.org).

DISCUSSION

Dr Ali F. AbuRahma (Charleston, WVa). This is the only large series, actually, that I see in the last 8 years that presents a decent experience about causalgia since we presented our data to this group over 9 years ago. One thing I would like to reemphasize for the group of people here is that the timing between initial injury and the initial treatment, whether a chemical or surgical sympathectomy, is absolutely critical, if you really want to make sure that you do not get negative results. And as part of that, I have quite a few questions for you.

Have you encountered anything of this entity after lumbar laminectomies? I noticed you indicated type of injury, but I have not seen any in your slide or even in the manuscript about the causalgia after lumbar laminectomy, and we have seen a few of these.

I noticed also in your manuscript that you resected L1 through L4. And generally we like to get L2 and L3, unless the pain is really impressive, extensive, from the upper thigh all the way down to the foot. Otherwise, we do not go that extensive. Have you considered contralateral lumbar sympathectomies for people who failed? I am sure you are aware of the fact of the contralateral cross fibers and fibers from one side to the other. For the people who failed, would you have thought of contralateral lumbar sympathectomy?

Have you had any experience with the laparoscopic retroperitoneal lumbar sympathectomy of which we had few?

And finally, I did like what I saw in terms of your referring to the complex regional pain syndrome. I see it is somewhere in the manuscript, but I would like really to emphasize maybe a little more comment on it, because we are dealing with multiple colleagues and many of them deny these terms and they like to use complex regional pain syndrome.

Dr Dennis F. Bandyk. We have observed postsympathectomy neuralgia after lumbar sympathectomy in 19% of patients. As I indicated, it was self-limiting and manifested as primarily thigh pain.

We tried to excise as much of the lumbar sympathetic chain as possible and have not performed any contralateral sympathectomies in this patient group.

We have not, in this series, performed any laparoscopic sympathectomies to date, but I think this procedure would be less invasive and it is something we would certainly look into in the future.

In respect to the term "complex regional pain syndrome:" it refers to a larger group of pain patients, some of whom may have sympathetic independent pain. Most pain clinic specialists, such as the RSD Association, when they identify a patient with sympathetically mediated pain, would use the term RSD to describe those patients.

Dr Josi Fernandez (Lisbon, Portugal). We have a similar experience, and I have been dealing with this kind of patient for a few years. One of the difficulties is to correlate pain with hyperactivity of the sympathetic system. One of the clinical signs that I found very useful is the presence of coldness and excessive sweating, and these signs have shown to be predictors of a good and durable response to sympathectomy.

Did you have the same experience as well, or do you just rely on the effect of sympathetic block?

Dr Bandyk. Dr Fernandez's question is whether or not other signs of autonomic hyperactivity are commonly present in these patients. We have observed these signs in the minority of the patients. If present, such signs of excess sympathetic system activity would indicate those patients as very good candidates for sympathectomy. In the majority of patients, the criteria of more than 50% pain reduction after a sympathetic block can be used to indicate sympathetic-maintained pain syndrome.

Dr James M. Malone (Scottsdale, Ariz). Very nice paper, one I think that is really important for vascular surgeons who on the average do not see many patients with RSD. I came to the microphone to echo one of your points and to ask a question.

You mentioned how minimal the trauma can be that induces RSD. I am sure in Florida you have as many insects as we have in Arizona. I have seen three patients in 6 months with insect bites as the precipitator of RSD, which to me was absolutely amazing.

The question has to do with the timing. Your data were broken down into rather long time periods traditionally for the treatment of RSD, and so this may be an unfair question. But most people who talk about success rates focus on 6 months as the drop-dead period in which to do surgery, and I wonder if you could make any comments?

Dr Bandyk. The shortest duration of RSD prior to sympathectomy was a patient who had his injury 6 months beforehand. Most patients had RSD for a longer time, and their disease process was more advanced. Some of these patients have undergone as many as 60 sympathetic blocks. The choice of less or greater 18-month time intervals for duration of RSD was arbitrary but allowed us to have equal numbers of patients in the two time periods, and statistical analysis indicated differences in outcome relative to duration of RSD symptoms.

Dr Samuel S. Ahn (Los Angeles, Calif). I had not planned to rise, but since you quoted me, I wanted to make a few corrections on the techniques they described. Over the years, I have refined the technique, so it is now a little different.

First of all, the port placement is very critical. And I put the ports as far posterior as I can so that the lung, which falls anterior, is not in the way. I use the mid chest line for the first port, the posterior chest line for the second port, and then the anterior chest line for the third port.

Secondly, I use sharp dissection preferentially. I use electrocautery as little as possible, only as necessary. I do not cauterize anywhere near the nerves. I think that is important to prevent any postoperative neuralgia. Since adopting this policy 3 years ago, I have not seen any postoperative neuralgia.

Thirdly, I now use 7-mm ports for 5-mm instruments and that has allowed me to discharge these patients home on the same day as the operation. The chest tube comes out in the recovery room if there is no air leak, and 95% of patients go home the same day. I think you had 2 to 4 days in the hospital.

I was a little curious about your RSD patients that had these worsening migratory symptoms. How do you know that these patients did not have this systemic RSD to start with and were not already in the process of developing further symptoms? You implied that your surgery may have induced it somehow. So the question to you is, how can you differentiate preexisting from induced RSD?

The final comment is that I noticed that two thirds to three quarters of RSD patients have a positive stress test for thoracic outlet syndrome (TOS). Conversely, some of my TOS patients present with RSD. If I just take out their first rib and decompress their TOS, their RSD resolved in most cases. Have you noticed this in your patient population? Did any of your patients have underlying TOS that may have accounted for their RSD?

Dr Bandyk. We have observed your changes in the port position and size of the camera port. I agree port placement is important.

Relative to length of stay, there is a difference in patients who undergo sympathectomy for RSD versus hyperhidrosis. The hyperhidrosis patients, they go home earlier, usually the next day. But the RSD pain patients we have treated usually require morphine pumps after the surgery and are discharged from the hospital in 2 to 3 days.

Fifteen of our patients presented with bilateral symptoms and had RSD that progressed. Even after one limb was treated and pain reduction occurred, some of these patients were nonresponders in the contralateral limb. We have found that patients who are nonresponders frequently do not respond to other treatments. We have performed first rib resections with no improvement. Six of the nonresponding patients had spinal cord stimulators placed, and only one benefitted. A number of the patients had been prescribed narcotic pumps at home with short-term success. RSD nonresponders remain a difficult group of patients to manage.