ORIGINAL ARTICLE

Radiofrequency Thoracic Sympathectomy for Sympathetically Maintained Chronic Post-Mastectomy Pain, a Preliminary Report: 6-Month Results

Diab Fuad Hetta, MD*; Ashraf Amin Mohamed, MD*; Helal F. Hetta [ID], PhD[†,‡]; Essam Ezzat Abd EL-Hakeem, MD[§]; Madona Misheal Boshra, MM[¶]; Mohamed Moamen El-Barody, MD**; Montaser A. Fattah Mohammad, MD*

*Department of Anesthesia and Pain Management, South Egypt Cancer Institute, Assuit University, Assiut, Egypt; †Department of Internal Medicine, University of Cincinnati College of Medicine, Cincinnati, Ohio U.S.A.; ‡Department of Medical Microbiology and Immunology, Faculty of Medicine, Assiut University, Assiut; §Department of Anesthesia and Intensive Care, Assuit University Hospital, Assuit University, Assiut; ¶Department of Anesthesia and Pain Management Department, South Egypt, Cancer Institute, Assuit University, Assiut; **Department of Radiodiagnosis, South Egypt, Cancer Institute, Assuit University, Assiut, Egypt

■ Abstract

Aim: Evaluation of the analgesic efficacy of radiofrequency thoracic sympathectomy for sympathetically maintained post-mastectomy pain syndrome (PMPS).

Methods: Patients with PMPS randomized to Group TS (*n* = 33) received radiofrequency thoracic sympathectomy, and those randomized to Group Sham (*n* = 33) received no radiofrequency current. Postoperative pain treatment consisted of duloxetine, pregabalin, and tramadol for both groups. The outcome variables were the proportion of patients who showed >50% reduction in their VAS pain score, the pain intensity measured by VAS score, and the global perceived effect (GPE) evaluated during the 6-month follow-up period.

Results: A significantly higher proportion of patients experienced >50% reduction in pain in Group TS (Group TS 25/30 [83.3%] vs. Group Sham 18/31 [58%], *P* = 0.032); the proportion of patients who experienced >50% reduction in their pain without analgesics was significantly higher in Group TS (Group TS 10/25 [40%] vs. Group Sham 0/18 [0%], *P* = 0.001). Furthermore, the proportion of patients treated with tramadol + duloxetine + pregabalin who experienced >50% reduction in their pain was significantly lower in Group TS (Group TS 0/25 [0%] vs. Group Sham 13/18 [75%], *P* = 0.001). The VAS pain score was significantly lower in Group TS at 2 weeks and at 1, 2, 3, and 6 months following the procedure. The GPE was significantly higher in Group TS (Group TS median GPE [interquartile range]) 7 [5, 7] vs. Group Sham median GPE [interquartile range]) 5 [4, 6]) *P* < 0.001).

Conclusions: Radiofrequency thoracic sympathectomy for sympathetically maintained PMPS decreased VAS pain scores and reduced the need for anti-neuropathic drugs, particularly opioid medications, and provided better patient satisfaction. ■

INTRODUCTION

Breast cancer is the most common reason for cancer-related deaths in women worldwide,[1] and most of the cases are treated surgically with lumpectomy or modified radical mastectomy.[2] Unfortunately, 20% to 68% of these patients experience chronic post-mastectomy pain syndrome (PMPS).[3] The International Association for the Study of Pain defined PMPS as chronic pain in the anterior aspect of the thorax, axilla, and/or upper half of the arm beginning after mastectomy or quadrantectomy and persisting for more than 3 months.[4]

PMPS fluctuates from mild to severe, intermittent or continuous, with periods of worsening and improvement.[5] PMPS leads to temper change, difficulty with physical activity, and reduction in individual satisfaction.[6]

A diversity of drugs—N-methyl-d-aspartate receptor antagonists,[7] gabapentinoids,[8] venlafaxine[9]—and nerve block[10] have been tried for prevention of PMPS in the perioperative period, and several drugs have been used for treatment with varying degrees of success, including amitriptyline,[11] venlafaxine,[12] and levetiracetam.[13]

A sympathetic sprouting and sympathetic-sensory coupling have been observed in the dorsal root ganglion (DRG) and peripheral tissue in experimental chronic pain models.[14–16] Such observation provided a possible explanation for clinical syndromes of sympathetically maintained pain.[17] Many chronic pain conditions such as complex regional pain syndrome (CRPS) have long been known to be maintained or exacerbated by sympathetic activity, especially at earlier stages,[18] and to respond to various methods of reducing sympathetic input.

Previous studies have demonstrated the analgesic efficacy of stellate ganglion block for PMPS.[19] Since relief of symptoms after sympathetic efferent blockade is the most definitive indicator of sympathetically maintained pain,[20] we believed that PMPS that was refractory to anti-neuropathic medications and had responded to sympathetic block could be treated with radiofrequency (RF) denervation of thoracic sympathetic ganglia (T2, T3, and T4).

METHODS

After obtaining approval from the ethical committee of our institutional review board and obtaining informed written consent from each patient, which included an explanation of the procedure, the benefits, and the risks and alternatives, 66 patients complaining of chronic post-mastectomy pain were included. The current study was a prospective randomized controlled clinical trial (registered at Clinical Trial.gov, unique ID: NCT03494426) and was conducted according to the CONSORT standard for clinical trial reporting.

Inclusion criteria were adult, female patients complaining of chronic post-mastectomy pain with a duration of pain $\geq$ 6 months and with a VAS pain score $\geq$ 5 on a scale of 0 to 10 despite treatment with first-line anti-neuropathic drugs, including serotonin-norepinephrine reuptake inhibitors, duloxetine (up to a dose of 60 mg daily), and/or pregabalin (up to a dose of 150 mg daily). The post-mastectomy pain seemed to be of neuropathic origin based on the Douleur Neuropathique 4 questionnaire score of $\geq$4, and the pain was located in the ipsilateral breast/chest wall, axilla, and/or arm, and occurred at least 50% of the time. Moreover and importantly, the included participants should get more than 50% reduction of their pain for 24 hours in response to thoracic sympathetic block performed at T2 with 6 mL of 0.5 % bupivacaine.

Exclusion criteria included any prior interventional pain procedure for chronic post-mastectomy pain; local pathology such as recurrent cancer or chronic infection in the breast region that could be responsible for the persistence of symptoms; abnormal anatomy of the thoracic vertebrae, such as scoliosis or severe kyphosis; infection at the site of needle entry; pregnant women; uncorrected coagulopathy; severe cardio-pulmonary compromise; and hypersensitivity to any drugs used throughout the study.

The included patients were randomly assigned into 2 equal groups. Using a computer-generated list of numbers masked in opaque sealed envelopes that were opened immediately prior to the intervention, Group TS (*n* = 33) received thoracic sympathectomy and Group Sham (*n* = 33) received no RF current.

The procedure was performed in the pain interventional unit, which was equipped with an anesthesia machine, monitor, and fluoroscopy and RF apparatus. The patient was positioned prone on the operating table, basic monitors (pulse oximeter, ECG, and noninvasive blood pressure) were attached to the patient, and a nasal cannula delivering oxygen at a flow of 4 L/min was fixed. An intravenous cannula was inserted and secured in place, and then 3 mg of midazolam for sedation and 1 mg/kg of ketamine for analgesia were administered just

before RF denervation. The upper thoracic spine was disinfected and draped. An anterior-posterior (A-P) fluoroscopic image was taken to determine the area of focus (upper 4 thoracic vertebrae), and the first thoracic vertebra was identified by its characteristic upward directed and ballooned transverse process that distinguishes it from the last cervical vertebra, which slants downward (Figure 1).

The C-arm was adjusted in a caudo-cephalic orientation to align the lower end plate of the concerned vertebra, then it was directed 10 degrees caudally. After that, the C-arm was oriented 15 degrees obliquely on the transverse plane, and the skin entry point was determined just lateral to the vertebral body shadow and immediately below the rib shadow (the angle formed by the rib and vertebral shadow); 2 mL of 1% lidocaine was infiltrated at each level (Figure 2). A 20-gauge RF needle, 10 cm in length with a 1-cm active curved tip, was introduced (end-on) at the desired entry point, then the C-arm was turned to the lateral view to check the needle depth; the final needle tip position was at the posterior third of the vertebral body shadow, just below the level of the pedicle, which is the common site of sympathetic ganglia[21] (Figure 3). After that the needle tip was checked in the A-P image (should be situated 0.2 to 0.5 cm lateral to the shadow of the vertebral body; see Figure 1). When the 3 RF needles were situated in
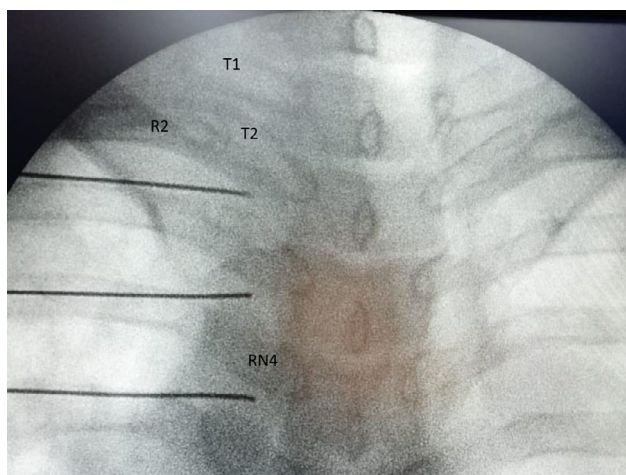

Figure 2. An oblique x-ray view of the spine depicting the radiologic anatomy of the upper thoracic region and needle entry point. R1, R2, R3, and R4 = the ribs from 1 to 4. T1, T2, T3, and T4 = thoracic vertebrae from 1 to 4. RFN = the 3 radiofrequency needles, targeting the second, third, and fourth sympathetic ganglia; the C-arm is adjusted for the lowermost needle (end-on).

Figure 1. An anteroposterior x-ray view of upper thoracic spine depicting the final needle tip position for radiofrequency (RF) thoracic sympathectomy. R2, second rib; RN4, RF needle tip is situated just below the head of the fourth rib; TI, transverse process of the first thoracic vertebra (upward slanted and inflated tip, differentiated from the last cervical transverse process, which slants downward); T2, transverse process of the second thoracic vertebra.
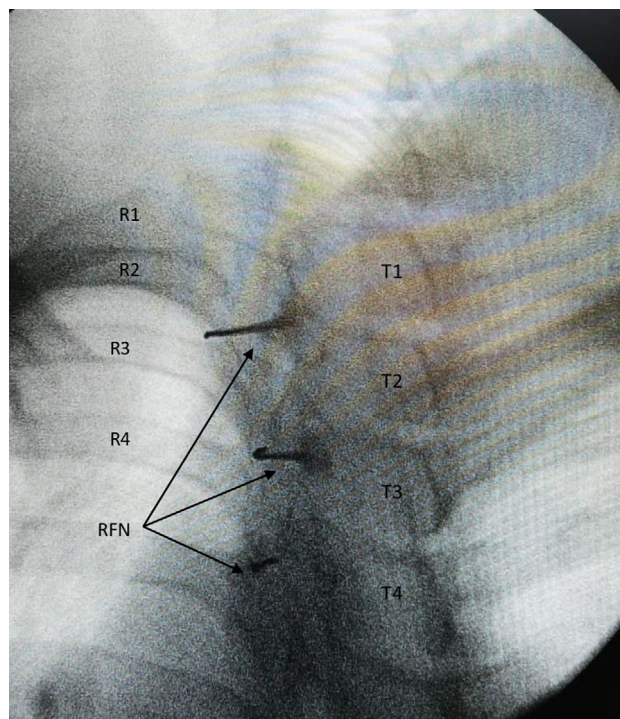
place and before lesioning, a sensory testing (at 50 Hz, up to 0.6 V) and motor test stimulation (at 2 Hz, up to 1.2 V) was performed to verify the location. If the patient experienced no dermatome-related sensation and had no intercostal muscle contractions, the needle positions were deemed satisfactory and at a safe distance from the thoracic nerve root.[22] Then 1 mL radioopaque dye was injected to exclude an intra-vascular or intra-pleural location (Figure 4). Finally, sympathetic denervation was accomplished by delivering the RF current for 120 seconds at 80°C. Then we waited for 5 minutes until the manifestation of sympathetic block appeared in the ipsilateral hand (rise of skin temperature of about 2°C in comparison to the other hand, measured with a skin thermometer); if the manifestations of sympathetic denervation did not appear in the ipsilateral arm, the needle hub was rotated 180 degrees in a mediocaudal direction and another 120 seconds of RF current at 80°C was delivered. For Group Sham, the same steps were followed, including sedation with midazolam and ketamine, but the needles were situated in the
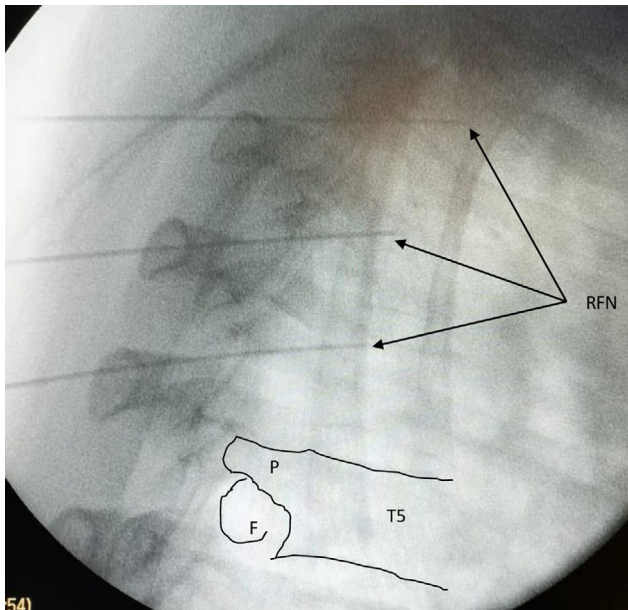
Figure 3. Lateral x-ray view of upper thoracic spine depicting the final needle tip position for radiofrequency thoracic sympathectomy. F, intervertebral foramen; P, pedicle; RFN, final needle tip position of the 3 radiofrequency needles (posterior third of the vertebral body at the level of the pedicle); T5, body of the fifth thoracic vertebra; .
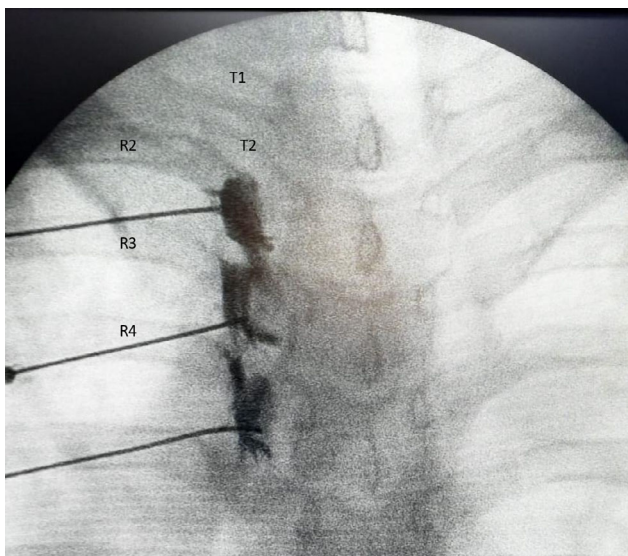

Figure 4. An anteroposterior x-ray view of the upper thoracic spine depicting the final needle tip position and dye delineation of the upper thoracic sympathetic ganglia. R2, R3, and R4 = the second, the third, and the fourth ribs. TI, transverse process of the first thoracic vertebra; T2, transverse process of the second thoracic vertebra.

subcutaneous tissue and without delivering the RF current. Finally, the needles were removed and the skin was covered by a sterile patch. The operated patient was

transferred to the observation room, where radiography was requested to exclude any possibility of pneumothorax, and discharged after 24 hours.

The post-procedural follow-up included assessing the change of pain intensity on the VAS at 2 weeks and at 1, 2, 3, and 6 months following the procedure. The long-term, post-procedural analgesic treatment consisted of a continuation of the preprocedural treatment (duloxetine and pregabalin), titrated according to the response, and sustained-release tramadol was introduced as a second-line treatment starting with a dose of 50 mg twice daily and titrated according to the response every 2 days up to a maximum 400 mg daily. The primary outcome variable was the proportion of patients who showed >50% reduction in their VAS pain score (from baseline values), measured at 6 months post-procedure. The secondary outcome variables were the changes in level of pain intensity measured by the VAS at 2 weeks and at 1, 2, 3, and 6 months following the procedure, the proportion of patients who discontinued their preprocedural analgesics, and the global perceived effect (GPE) assessed at 6 months following the procedure. The GPE was assessed using a 7-point Likert-like verbal rating scale where 1= extremely dissatisfied, 2 = dissatisfied, 3 = somewhat dissatisfied, 4 = undecided, 5 = somewhat satisfied, 6 = satisfied, and 7 = extremely satisfied. Breast cancer–related lymphedema (BCRL) of the affected arm was clinically diagnosed when there was a circumference difference in the forearm ($\geq$2 cm) compared to the healthy side. The preprocedural measurements were compared with the measurement obtained 6 months after the procedure to detect its course. The data were described as no change, increased, or decreased during this period. Patients in both groups were treated with physical therapy, bandaging of the arm, compression garments, and massage.

After the completion of the study (6-month follow-up), patients who did not experience pain reduction (VAS score > 50% of its basal value) received either medical treatment in the form of morphine sustained-release tablet (MST) or interventional treatment in the form of pulsed RF on the thoracic paravertebral nerve at T2, T3, and T4 or DRG at T2, T3, and T4.

Statistical Analysis

Statistical analysis was carried out on a personal computer using SPSS version 24 (IBM Corp., Armonk, NY, U.S.A.). The normality of continuous data distribution was examined via the Shapiro-Wilk test prior to

further statistical analysis. Categorical data were described as number and percentage, and comparisons were made by chi-square and Fisher's exact tests. Continuous data were described as mean ± standard deviation (SD) or 95% confidence interval (CI), and point-by-point comparison was done by unpaired Student's *t*-test. A linear general model for repeated measures was used for analysis of VAS pain scores over time (2 weeks and 1, 2, 3, and 6 months following the procedure), examining the following effects: group, time, and group-by-time interaction. Medians and interquartile ranges were used for skewed data, GPE and comparisons were made using the Mann-Whitney *U* test. $P < 0.05$ was considered statistically significant.

Based on our institutional work, we believed that a sample size containing 30 patients in each group would detect 35% difference in the proportion of patients showing a reduction of more than 50% in their VAS scores at 6 months post-procedure, assuming a confidence level of 95% and a study power of 85%. Type 1 error was set at 5% and the P value was considered significant at a level of <0.05. To account for dropouts, we enrolled 33 patients in each group.

RESULTS

Eighty patients were assessed for eligibility, 14 of whom showed a negative response to thoracic sympathetic block; 66 patients were allocated into 2 equal groups, 33 patients in each group. One patient in Group TS was excluded due to a technical failure in the RF generator during the procedure, and 4 patients were lost to follow-up (2 in each group). Ultimately, 30 patients in Group TS and 31 patients in Group Sham remained for analysis (Figure 5).

There was not a statistically significant difference between the 2 groups with respect to mean years of age (Group TS vs. Group Sham: 50.8 ± 5.3 vs. 50.7 ± 6.6; $P = 0.936$) and mean body mass index (kg/m^2) (Group TS vs. Group Sham: 30.5 ± 3.7 vs. 31.1 ± 3.8; $P = 0.561$).

Six months after the procedure, we found that a significantly higher proportion of patients experienced a
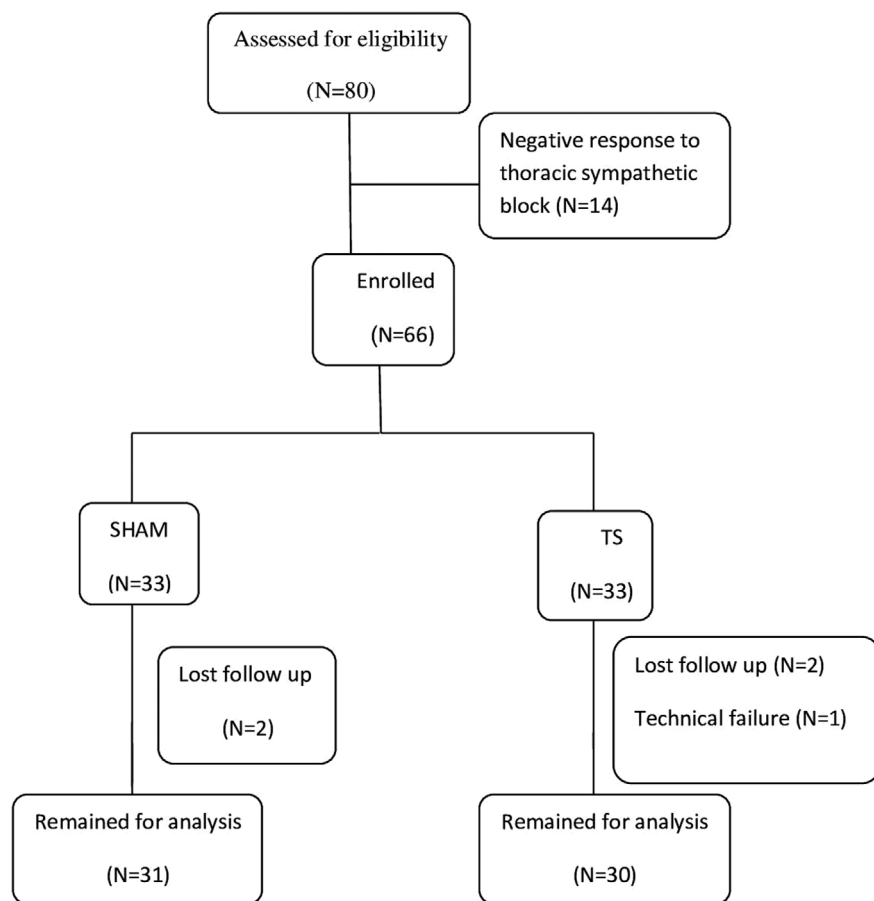

Figure 5. Flow chart of participants through the study. TS, thoracic sympathectomy.

more than 50% reduction of their pain in Group TS compared to Group Sham (Group TS 25/30 [83.3%] vs. Group Sham 18/31 [58%], $P = 0.032$). Among patients in Group TS who experienced >50% pain relief, 10/25 (40%) did not require any analgesics, 8/25 (32%) required duloxetine only, 3/25 (12%) required pregabalin only, 4/25 (16%) required duloxetine + pregabalin, and none required tramadol. Among patients in Group Sham who experienced >50% pain relief, 13/18 (75%) required a combination of tramadol, pregabalin, and duloxetine, 1/18 (5%) required duloxetine only, and 4/18 (20%) required a combination of duloxetine and pregabalin (Table 1).

Analysis of VAS pain scores over time (2 weeks and 1, 2, 3, and 6 months following the procedure) using the general linear model revealed statistically significant overall group differences (mean ± standard error [95% CI]: Group TS 3.2 ± 0.211 [2.7, 3.6] vs. Group Sham 4 ± 0.208 [3.6, 4.4], $P = 0.007$). Moreover, there were significant time and group-by-time interaction effects: the VAS score decreased over time (2 weeks and 1, 2, 3, and 6 months) in both groups, and this decrease was greater in Group TS when the tests of within-subject effects and within-subject contrasts were applied ($P < 0.001$). Further point-by-point comparisons of the means of VAS pain scores between groups (at 2 weeks and at 1, 2, 3, and 6 months following the procedure) using the independent-samples t-test revealed a statistically significant reduction in VAS scores in Group TS vs. Group Sham, respectively, at all time points (mean ± SD [95% CI of the mean difference]): at 2 weeks (3.17 ± 1.64 vs. 4.35 ± 1.14, -1.2 [-1.9, -0.47], $P = 0.002$), at 1 month (2.67 ± 1.42 vs. 4.06 ± 1.09, -1.4 [-2.04, -0.75], $P = 0.001$), at 2 months (2.43 ± 1.45 vs. 3.35 ± 1.28, -0.92 [-1.62, -0.22], $P = 0.011$), at 3 months (2.13 ± 1.42 vs. 2.96 ± 1.18, -0.83 [-1.5, -0.16], $P = 0.016$), and at 6 months (2.07 ± 1.53 vs. 2.9 ± 1.15, -0.87 [-1.56, -0.18], $P = 0.015$) (Table 2).

As regards the patient's satisfaction (GPE) assessed at 6 months post-procedure, there was significantly higher satisfaction in Group TS compared to Group Sham, respectively (median [IQR]: 7 [5, 7] vs. 5 [4, 6], $P < 0.001$).

Regarding the effect of the procedure on BCRL of the upper limb, 8 of 11 patients in Group TS (72.7%) showed improvement compared to 2 of 10 patients in Group Sham (20%) ($P = 0.018$), and no change in the course of lymphedema was observed in 3 of 11 patients in Group TS (27.3%) compared to 4 of 10 patients in Group Sham (40%) ($P = 0.547$). However, 4 of 10 patients in Group Sham (40%) showed a worsening course compared to 0 of 11 patients in Group TS (0%) (see Table 1).

Regarding the effects of thoracic sympathectomy on hemodynamics, we did not detect significant changes in heart rate or blood pressure between groups after denervation (Table 3).

DISCUSSION

Most patients who present to pain clinics with PMPS respond to anti-neuropathic drugs, specifically the first-line treatment, tricyclic anti-depressants, amitriptyline, serotonin-norepinephrine reuptake inhibitors (SNRIs), duloxetine, and gabapentinoids. Regrettably, some cases of PMPS do not respond to the aforementioned treatment. The subsequent step in management is to introduce tramadol as a second-line anti-neuropathic agent or to consider nerve block and neuromodulation.[23] In our recent work, we applied pulsed RF on the thoracic paravertebral nerve (T2, T3, and T4) or the corresponding DRG and achieved good results.[24] In this trial, patients with PMPS who did not respond to the first-line anti-neuropathic drugs and before treatment with an opioid (tramadol) were subjected to thoracic sympathetic block. We believed that patients with PMPS who responded to sympathetic block (>50% reduction of their pain within 24 hours) had sympathetic

Table 1. The Analgesic Profile and BCRL at 6-Month Follow-Up

Variable	Group TS (n = 30) (n, %)	Group Sham (n = 31) (n, %)	P Value
Reduction of VAS score > 50%	25/30 (83.3)	18/31 (58)	0.032
No required analgesics	10/25 (40)	0/18 (0)	0.001
Required (tramadol + duloxetine + pregabalin)	0/25 (0)	13/18 (75)	0.001
Required duloxetine only	8/25 (32)	1/18 (5)	0.033
Required pregabalin only	3/25 (12)	0/18 (0)	0.132
Required duloxetine + pregabalin	4/25 (16)	4/18 (20)	0.737
Failed reduction of VAS score > 50%	5/30 (16.67)	13/31 (41.91)	0.032
Received MST	1/5	3/11	
Received PRF on PVN	3/5	3/11	
Received PRF on DRG	1/5	7/11	
BCRL	11/30 (36.7)	10/31 (32.3)	0.720
Decreased	8/11 (72.7)	2/10 (20)	0.018
No change	3/11 (27.3)	4/10 (40)	0.547
Increased	0/11 (0)	4/10 (40)	0.023

BCRL, breast cancer–related lymphedema; DRG, dorsal root ganglion; MST, morphine sustained release tablet; PRF, pulsed radiofrequency; PVN, paravertebral nerve; TS, thoracic sympathectomy.

Table 2. Visual Analogue Pain Scale (VAS) Scores During the Post-Procedural 6-Month Follow-Up

Variable	Group TS (n = 30)	Group Sham (n = 31)	Mean Difference (95% CI)	P Value
VAS score, basal	6.5 ± 1.07	6.45 ± 0.99	0.05 (−0.48, 0.58)	0.86
VAS score, 2 weeks	3.17 ± 1.64	4.35 ± 1.14	−1.2 (−1.9, −0.47)	0.002
VAS score, 1 month	2.67 ± 1.42	4.06 ± 1.09	−1.4 (−2.04, −0.75)	0.001
VAS score, 2 months	2.43 ± 1.45	3.3 ± 1.28	−0.86 (−1.55, −0.16)	0.016
VAS score, 3 months	2.13 ± 1.46	2.96 ± 1.17	−0.83 (−1.5, −0.16)	0.016
VAS score, 6 months	2.07 ± 1.53	2.9 ± 1.15	−0.87 (−1.56, −0.18)	0.015

Data are presented as mean ± standard deviation, mean difference (95% confidence interval).
CI, confidence interval; TS, thoracic sympathectomy.

overdischarge that was responsible for the persistence of their pain and resistance to treatment and could gain long-term analgesia from thoracic sympathectomy.

The percutaneous RF thoracic sympathectomy performed in this study decreased chronic post-mastectomy pain, reduced the need for anti-neuropathic and opioid medications, and provided a better quality of life and patient satisfaction when compared to patients in Group Sham within the 6-month follow-up period.

The intensity of pain decreased over time in both groups; however, when the 2 groups were compared, thoracic sympathectomy achieved a statistically significant pronounced pain reduction without the need for opioid (tramadol) or multiple anti-neuropathic drugs. In about 60% of the patients in Group TS, their pain was controlled with duloxetine (32%), pregabalin (12%), or duloxetine + pregabalin (16%), and none of the patients required tramadol. Moreover, 40% of patients did not require any analgesics. In contrast, in 75% of the patients in Group Sham, their pain was controlled with a combination of tramadol, duloxetine, and pregabalin; 20% of patients required a combination of duloxetine and pregabalin and 5% of patients required duloxetine only to control their pain.

Table 3. Perioperative Hemodynamics

Variable	Group TS (n = 30)	Group Sham (n = 31)	P Value
Preoperative SBP	133 ± 19	130 ± 14	0.59
Postoperative SBP, 0H	131 ± 14	129 ± 11	0.63
Postoperative SBP, 2H	129 ± 14	127 ± 10	0.62
Preoperative DBP	84 ± 11	78 ± 11	0.06
Postoperative DBP, 0H	81 ± 8	78 ± 9	0.09
Postoperative DBP, 2H	81 ± 9	77 ± 8	0.95
Preoperative HR	82 ± 12	79 ± 12	0.32
Postoperative HR, 0H	81 ± 11	83 ± 9	0.54
Postoperative HR, 2H	78 ± 9	79 ± 7	0.45

Data are presented as mean ± standard deviation.
0H, immediately after denervation; 2H, 2 hours after denervation; DBP, diastolic blood pressure; HR, heart rate; SBP, systolic blood pressure; TS, thoracic sympathectomy.

PMPS has been previously treated with stellate ganglion block.[19] Regrettably, stellate ganglion block interrupts the sympathetic supply of the upper arm in only 80% of populations due to Kuntz fibers; sympathetic fibers from T2 and T3 directly supply the brachial plexus without passing through the stellate ganglion.[25] Moreover, it does not interrupt the sympathetic supply of the upper chest (breast region). So we believe that the analgesic benefit reported in these studies is attributed to caudal spread of local anesthetic to the thoracic sympathetic chain and not simply due to stellate ganglion block.

In contrast, thoracic sympathectomy consistently interrupts the sympathetic supply to the upper limb and upper chest.[26] Chronic post-mastectomy pain is primarily due to surgical injury of the intercostobrachial nerve that occurs during removal of breast tissue and axillary lymph nodes en bloc in modified radical mastectomy or during 21 quadrantectomy with axillary lymphadenectomy.[27] The intercostobrachial nerve is formed by the roots of T2, T3, and, uncommonly, T4,[5] so RF lesioning of T2, T3, and T4 sympathetic ganglia will interrupt sympathetic fibers carried through the intercostobrachial nerve; consequently, complete sympathetic denervation of the painful region (upper chest, axilla, and upper arm) occurs.

Thoracic sympathetic block has been a useful therapeutic procedure for pain treatment, including CRPS, postherpetic neuralgia, and peripheral vascular disease of the upper extremities.[28–30] The aforementioned studies concluded that to achieve a sustained analgesic benefit from thoracic sympathetic block with local anesthetic only, it should be repeated. So RF lesioning of the thoracic sympathetic chain could provide cessation of sympathetic firing for a longer duration beyond that from local anesthetic block.

McLachlan et al.[31] first described abnormal sprouting of sympathetic fibers into the DRG after cutting the

sciatic nerve. Subsequent studies have shown that such sprouting occurs in many animal pain models.[32,33] This may include formation of dramatic "basket" formations in which sympathetic fibers form a dense plexus around individual somas (particularly of large diameter cells), and/or an increase in overall sympathetic fiber density in the cellular region of the DRG. Basket structures have also been observed in the DRG of patients with neuropathic pain.[34] Sympathetic fibers in the DRG originate in the grey ramus, which enters the spinal nerve close to each DRG.[31–34] Sprouting may occur from the fibers that are already present in the DRG and normally innervate the blood vessels, or as newly growing collateral fibers from other more distal sympathetic fibers.[35]

Many chronic pain conditions such as CRPS have long been known to be maintained and exacerbated by sympathetic activity in some patients, especially at earlier stages,[17] and to respond to various methods of reducing sympathetic input. So we attribute the analgesic benefits depicted in the current study to reduction of sympathetic load carried through the intercostobrachial nerves.

The DRG is an attractive target for RF treatment because hyperactivity of DRG neurons has been identified as a cause for developing neuropathic pain.[36] In our study, however, it was not our first option and was reserved for unresponsive cases due to the technical difficulty in targeting the DRG of the upper thoracic spine.

Not only was the pain reduced and the need for analgesics lessened in Group TS, but the patient's satisfaction was better. The pain reduction over time in Group Sham necessitated multiple drugs, including duloxetine, pregabalin, and tramadol, which impaired quality of life due to their poor tolerability and well-known common side effects, specifically sedation and drowsiness.[37–39]

Regarding the effect of thoracic sympathectomy on BCRL of the upper arm, more patients improved in Group TS compared to Group Sham—8 of 11 patients showed decreased lymphedema in Group TS compared with 2 of 10 cases in Group Sham. Studies on BCRL revealed improved outcome; however, these studies recruited small samples and were not controlled.[40,41] Park et al.[42] compared the effects of a stellate ganglion block with complex decongestive therapy in 38 patients with BCRL, and they pointed out that both sympathetic block and complex decongestive therapy decreased limb circumference without a statistically significant difference between the 2 groups. Sympathetic blockade resulted in vasodilatation and improvement of the circulation of the upper arm; in addition, the decreased pain intensity allowed for better mobility that helped lymphatic drainage.

Although we had no cases that were complicated by pneumothorax, it remains a concern for any procedure posterior to the lung. Clinicians must be aware of some safety issues: (1) the needle insertion site should be within 4 cm of the thoracic spine; (2) the needle propagation through tissues should hug the lateral vertebral margin and the needle depth should be early checked by lateral fluoroscopic image; and (3) operated patients should be hospitalized for 24 hours to rule out any possibility of pneumothorax.

Future Studies

RF thoracic sympathectomy as described in this study should be attempted for CRPS and postherpetic neuralgia of the upper arm in which repeated sympathetic block has provided a beneficial analgesic effect.

Study Limitations

The current study is limited by a short (6-month) observation period. Also, we did not evaluate the effect of sympathectomy on quality of life. However, we did use the patient's satisfaction score as an indicator of quality of life. In addition, we did not inject local anesthetic or any particulate steroids to ameliorate postoperative soreness accompanying RF denervation to be sure that the obtained results were due to RF sympathectomy. The operated patients were not objectively assessed for anhidrosis. However, none of the operated patients complained of dryness of the ipsilateral arm.

CONCLUSION

RF thoracic sympathectomy for sympathetically maintained PMPS decreased VAS pain scores, reduced the need for anti-neuropathic drugs (particularly opioid medications), and provided better patient satisfaction.

FUNDING

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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