Randomized Control Trial

Early Evaluation of Thermal Radiofrequency vs. Chemical Neurolysis for T2 and T3 Sympathectomy in Post-Mastectomy Pain Syndrome Using Oximetry-Based Perfusion Index Assessment

Walaa Y. Elsabeeny, MD, Mahmoud S. Soliman, MD, Taher S. Thabet, MD, and Sayed M. Abed, MD

From: National Cancer Institute, Cairo University, Egypt

Address Correspondence:
Sayed M. Abed, MD
Department of Anesthesiology and Pain Management, National Cancer Institute, Cairo University, Cairo, Egypt
E-mail:
sayed.abed@nci.cu.edu.eg

Disclaimer: This trial was approved by the local institutional review board (decision number 2101-501-004). The trial was registered at clinicaltrials.gov (ID NCT04953507).

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Background: Post-mastectomy pain syndrome (PMPS) is a chronic neuropathic condition thought to be mediated mainly by the sympathetic nervous system. Effective treatment options for PMPS include T2 and T3 sympathectomy, performed through either thermal radiofrequency (TRF) or chemical neurolysis.

Objectives: This trial compares the efficacy of pulsed radiofrequency (RF) to that of neurolysis for post-mastectomy pain relief.

Setting: This double-blinded, randomized trial was conducted in the National Cancer Institute of Cairo, Egypt.

Methods: Fifty-four female patients with PMPS that did not respond to stellate ganglion blocks were included in the trial. Patients were assigned to receive either TRF (80° C for 120 seconds) or chemical neurolysis (phenol 8%) under fluoroscopic guidance. Primary outcomes included reduced scores on the Visual Analog Scale (VAS). Secondary outcomes included PI changes, skin temperature, opioid and pregabalin consumption, incidence of breakthrough pain, complications, and quality-of-life scores on the 36-Item Short-Form Survey (SF-36).

Results: Both TRF and chemical neurolysis resulted in significant pain reduction, with improvements ≥ 50% in VAS scores (77.8% [TRF] vs. 85.2% [neurolysis], $P = 0.484$). Perfusion index (PI) scores increased more rapidly in the neurolysis group at 5 minutes (5.9 ± 0.9 vs. 5.3 ± 0.7, $P = 0.008$) but were comparable at 20 minutes. Opioid consumption and breakthrough pain episodes significantly decreased in both groups after the procedures. The TRF group had fewer complications but required a longer procedural duration (22 ± 2 min vs. 16 ± 2 min, $P < 0.001$).

Limitations: This trial took place as a single center study and used a limited sample size.

Conclusion: Both TRF and chemical neurolysis are effective for T2 and T3 sympathectomy in the management of PMPS. Although neurolysis provides faster PI changes, TRF can offer a potentially safer profile. PI can serve as a reliable tool for the assessment of T2 and T3 sympathetic blocks.

Key words: post-mastectomy pain syndrome, sympathectomy, thermal radiofrequency, chemical neurolysis, perfusion index

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One of the common complications that follows breast cancer treatment is post-mastectomy pain syndrome (PMPS) (1). This neuropathic chronic pain condition is described as a dull aching, burning sensation in the axilla, arm, and anterior chest wall (2,3). PMPS is estimated to affect between 20 and 50 percent of patients who receive mastectomies (4,5).

Neuropathic pain is considered a sympathetic mediated pain (SMP), since the sympathetic nervous system plays a major role in neuropathic pain. SMP is thought to be effectively controlled through blocking the sympathetic fibers or ganglia that transmit signals from the affected area (6). The stellate ganglion is formed from the fusion of the lower cervical and first thoracic sympathetic ganglia. A stellate ganglion block (SGB) is performed for painful conditions that involve the head, neck, anterior chest wall, and upper limbs (7). Although SGBs can effectively relieve PMPS (8) not every patient who undergoes the procedures experiences a complete sympathetic block of the upper limb. This phenomenon may be explained by the presence of Kuntz's nerve, which bypasses the stellate ganglion (9).

Kuntz noticed that in approximately 20% of the population, the T2 and T3 sympathetic branches bypassed the stellate ganglion and joined the brachial plexus directly, which could explain the failure of or incomplete relief effected by the SGB in some patients (9,10). Neuropathic pain in the anterior chest wall and upper limb can be treated using a thoracic sympathetic block (11). Both chemical neurolysis and percutaneous radiofrequency (RF) have been used successfully in T2 and T3 sympathetic blocks (10). Chemical neurolysis is achieved through either alcohol 50-100% or phenol with glycerin 5-15% (12). Percutaneous radiofrequencies play an important role in managing SMP in patients who show inadequate responses to conservative management or who do not respond to it at all (13). Using the perfusion index (PI) derived from pulse oximetry can be a useful indicator to confirm the efficacy of a sympathetic block (7). The PI can be considered a reliable tool for measuring peripheral perfusion, since the index is a valid indicator of the changes in the strength of the pulse signal (7).

The aim of the current trial is to determine whether pulsed RF ablation provides PMPS patients with superior analgesic efficacy than that of chemical neurolysis, with pain reduction as the primary endpoint.

Methods

This double-blinded (both the patient and the outcome assessor were blinded) comparative trial was carried out at the National Cancer Institute after approval was obtained from the institutional review board (IRB approval no. 2101-501-004). The project was registered with Clinicaltrial.gov under the registration number NCT04953507 and was conducted from July 2021 to February 2025. A written informed consent form was taken from all patients included in the trial. Female patients who met the criteria for stages II or III on the American Society of Anesthesiologists' physical-status classification system, had been diagnosed with PMPS, and were between 18 to 70 years old were consecutively recruited and assessed for eligibility by a pain physician in the pain clinic. The trial included patients who suffered from PMPS in the upper anterior chest wall, axilla, or upper limb that did not respond to an SGB. (Those individuals were defined as patients who experienced < 50 % reductions in their visual analog scale [VAS] scores after the blocks.)

Patients' Recruitment

Fifty-four patients who met the eligibility criteria were recruited for the trial. Patients were excluded if they declined to participate or had coagulation disorders, abnormal kidney or liver function, local infections at the injection sites, vertebral bone metastases, or severe cardiorespiratory diseases.

At the pain clinic, patients recruited for the trial underwent an assessment that included a review of their general medical history, pain history, and medication usage. Additionally, laboratory tests and a physical examination were conducted to rule out any contraindications. Pain distribution was assessed, and affected areas were documented. Then, the recruited patients underwent counseling, provided informed consent, and were instructed to continue their regular medications, while patients on anticoagulants were instructed to manage their medications according to protocol.

Patients were allocated randomly, using computer-generated numbers. Upon arrival at the interventional pain unit theater and after the conditions were confirmed by the operating pain physician, each patient was assigned, using the closed-envelope technique, to one of the 2 trial groups. The procedures were conducted by an experienced pain physician, while a separate investigator, unaware of group allocation, collected the data.

In the interventional pain theater, before the blocks were started, all the patients were monitored by standard techniques (pulse oximetry, electrocardi-

ography, and noninvasive automated arterial blood pressure). A 20-gauge (G) intravenous line was inserted in the contralateral upper limbs and in the lower limbs of patients who had received bilateral mastectomies. Resuscitation equipment and drugs were prepared in case the patients needed them. Conscious sedation was used, as required, according to each patient's condition after proper evaluation by fentanyl (1 mic/kg) and midazolam (0.02 mg/kg).

Each patient was placed in a prone position with a small pillow under the chest. The area was sterilized and draped. A fluoroscopy C-arm was placed first in the anteroposterior position to visualize the vertebral bodies of C7, T1, T2, and T3. After the identification of the T2 vertebral body, the C-arm was moved in either a cranial or caudal direction to align the lower end plates of T2 and T3. This step was followed by ipsilateral oblique rotation of 15-20° to obtain an oblique view. The needle entry point was first infiltrated with a local anesthetic, then the needle (a 20-G, 9 cm spinal needle for patients who underwent neurolytic injections or a 20-G RF needle with a 10 mm active tip for patients who underwent RF lesioning) was advanced with tunnel vision (gun barrel) under fluoroscopic guidance to pass the skin and subcutaneous tissue. This needle maintained direct contact with the bone, targeting the lateral surface of the T2 vertebral body above the head of the third rib. The final needle position was checked in the lateral view, targeting the posterior third of the vertebral body. The procedure was then repeated at the level of T3. Under fluoroscopic guidance, the needle position was confirmed by the nonionic contrast omnipaque (iohexol), which was injected in both the anteroposterior (AP) and lateral views (Figs. 1A, 1B). To avoid the pneumothorax, the needle entry point was kept fewer than 4 cm from the midline (spinous process).

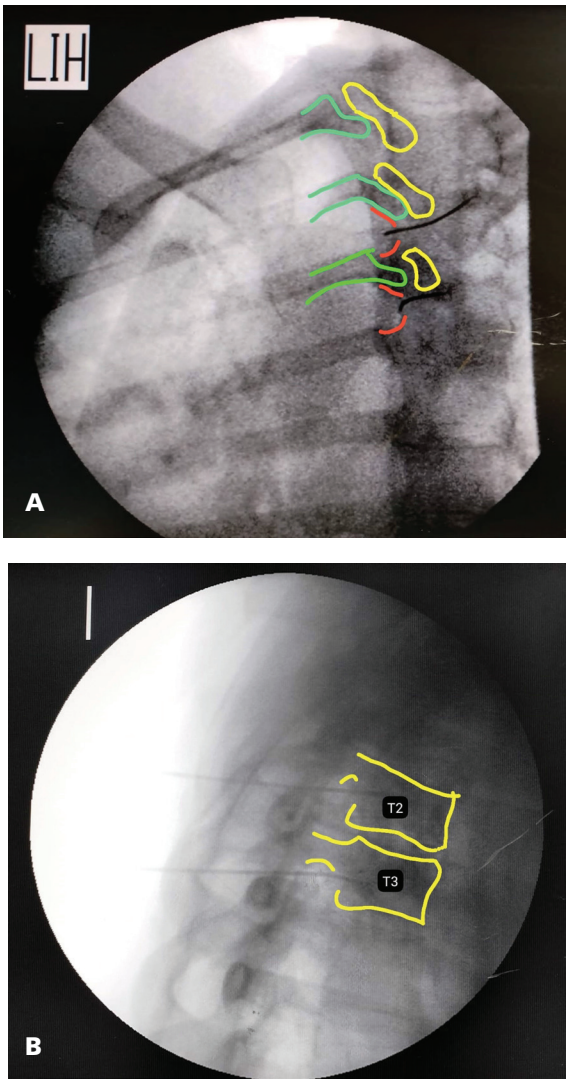

Fig. 1. *A) AP fluoroscopy view demonstrating the needle position. B) Lateral fluoroscopy view demonstrating needle position at the junction between the posterior third and anterior two-thirds of the T2 and T3 vertebral bodies.*

Group I: TRF Technique

RF sensory stimulation was done at 0.5-0.6 voltage and 50 Hz, followed by motor stimulation (1-1.2 voltage, 2 Hz). After it was confirmed that the intercostal nerves had received no stimulation, RF lesioning of 80°C was applied to the level of T2 for 120 seconds, and the same process was repeated at the level of T3.

Group II: Chemical Neurolysis Technique

After the needle position was confirmed by the nonionic contrast, 1.5 mL of the chemical neurolytic agent (phenol in saline 8%) were injected at each level.

Pulse oximetry sensors (Low Noise Cabled Sensors® connected to Masimo SET® Radical™ pulse oximeters, Masimo® Corporation) were used to measure the preprocedural PIs and temperatures of the normal and affected limbs, as were their post-procedural PIs and temperatures. The differences in PI were calculated at 5 and 20 minutes after the block. Temperatures were measured by General Electric temperature sensors (GE Appliances™).

Following the completion of the procedure, patients were transferred to the post-anesthesia care unit (PACU) for immediate postoperative monitoring. Pain levels were assessed using the VAS, and any pain requiring analgesia was documented. Neurological assessments were conducted to detect any sensory or motor deficits in the affected limbs. Patients were closely monitored for potential complications, including pneumothorax, lung injuries, local pain at the injection sites, and post-procedural neuralgia.

Outcome Measures

The primary outcome was the assessment of the VAS score. Secondary outcomes included changes in PI trends and the skin temperature of both upper limbs. For each patient, changes between both upper limbs and in the same limb were compared before and after the procedure. In addition to assessing patient satisfaction, the average consumption of opioids and pregabalin was evaluated before the intervention as well as at one week and 4, 8, 12, and 24 weeks after the procedure. The average opioid and pregabalin consumption were defined as the mean daily dose of opioid analgesics, measured in milligrams of oxycodone and pregabalin or their equivalents, taken by patients over the 3 days just before each follow-up interval. Additionally, the average incidence of breakthrough pain was documented as the mean number of episodes per day recorded over the 3 days immediately preceding each follow-up interval. Breakthrough pain was defined as sudden, transient pain exacerbations despite baseline analgesic treatment. That pain was assessed at baseline and at one week and 4, 8, 12, and 24 weeks after the procedure to evaluate changes in pain recurrence following the T2 and T3 sympathectomy blocks. Any complication related to the procedure (pneumothorax, lung injury, local pain, weakness of upper limb, post-procedural neuralgia) was reported. Patient satisfaction was classified as either one or 2: One meant the patient was satisfied with both the procedure and results, and 2 meant the patient was unsatisfied with the procedure, the results, or both.

The 36-Item Short Form Health Survey (SF-36) was used to evaluate the patients' quality of life (QoL). This questionnaire allows patients to report 8 key health-related aspects of their QoL, including physical functioning, role limitations caused by physical and emotional health conditions, bodily pain, general health, vitality, social functioning, and mental health (14).

Statistical Considerations

Sample Size Estimation

A previous study (15) indicated a 50% reduction in pain scores for 83% of patients treated with RF sympathectomies. Assuming that 40% of the patients in the neurolysis control group would experience a 50% reduction in pain scores, a continuity correction was applied, and the groups were of equal size, the study required 27 patients per group, with a total of 54 patients. This sample size ensures 80% power and a 5% significance level, allowing for the conclusion that RF outperforms neurolysis with a 10% superiority margin.

Statistical Analysis

IBM© SPSS© Statistics version 26 (IBM© Corporation) was used for statistical analysis. Quantitative data were expressed through either mean and standard deviation or median and range, while frequency and percentage were used to express qualitative data. The relation between qualitative variables was assessed using the chi-squared test (Fisher's exact test). Numerical data were compared using an independent sample t-test or a Mann–Whitney test. Two-way ANOVA was used to test the change of temperature in the 2 groups after 5 and 20 minutes. Repeated PI measures were compared using a separate analysis of variance (ANOVA) in each group, with correction of P-values because of interactions found on the 2-way ANOVA. A P-value < 0.05 was considered significant.

Results

Initially, 69 adult women were assessed for eligibility. Thoracic sympathetic nerve blocks were performed on 54 women. Each patient was allocated randomly to either the TRF and or the chemical neurolysis group until each group had 27 patients (Fig. 2). The 2 groups were comparable for their demographic data and disease duration. Because of the technique of RF stimulation and lesioning, the procedural duration experienced by the TRF group was significantly longer (22 ± 2 minutes) than that experienced by the neurolysis group (16 ± 2 minutes) (Table 1).

VAS Scores, Patients' Satisfaction, and Success Rate

Both groups were comparable in that they saw a ≥ 50% reduction in their VAS scores after 24 weeks. Patients' satisfaction and outcomes could also be compared between the groups. The 2 groups were

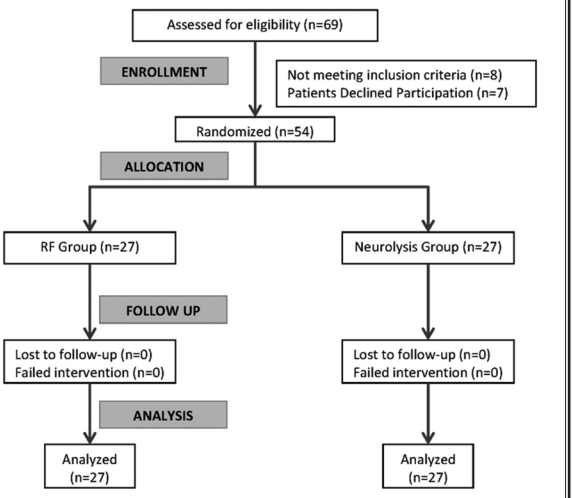

Fig. 2. *Flowchart of the patients' assignments to the trial groups.*

comparable through the observation period of up to 24 weeks. Over time, the evaluation of the VAS scores showed that compared to the baseline, the VAS scores decreased significantly in both groups up to 24 weeks ($P < 0.001$, for all comparisons). Success was defined as a > 50% drop in VAS score from the baseline after 24 weeks. The 2 techniques were equally effective ($P = 0.484$) (Table 1) (Fig. 3). The confidence interval (CI) of success in the 2 groups was the mean proportion of success, which was 77.8% (95% CI [57.7%-91.4%]) in the TRF group and 85.2% (95% CI [66.3%-95.8%]) in the neurolysis group.

Changes in the PI of the Affected Upper Limbs After the Thoracic Sympathetic Blocks

The range of pre-procedural PIs of the TRF group's affected limbs (1.5 ± 0.5) showed no significant difference from that of the neurolytic group (1.5 ± 0.3). However, after 5 minutes, the post-procedural PI of the neurolysis group (5.9 ± 0.9) was higher than that of the TRF group (5.3 ± 0.7) ($P = 0.008$). After 20 minutes, the post-procedural PI of the neurolysis group (6.2± 0.8) was comparable to that of the TRF group (6.0 ± 0.4) ($P = 0.256$) (Table 2) (Fig. 4). The changes in the affected limbs' PIs before the procedure and 5 minutes after it were significantly higher in the neurolysis group (4.4 ± 0.9) than in the TRF group (3.9± 0.8), p=0.044. However, PIs at 20 minutes after the procedure were comparable for both groups: patients in the TRF and neurolysis

Table 1. *Demographic data, disease duration, and procedural duration.*

		TRF Group (n = 27)	Neurolysis Group (n = 27)	*P*-value
Age (years)		46.9 ± 11.2	50.1 ± 10.5	0.275
Weight (kg)		74.8 ± 9.4	72.1 ± 8.3	0.265
Height (cm)		161 ± 5	163 ± 4	0.32
Disease Duration (years)		4 (1-7)	3 (2-7)	0.158
Procedure Duration (min.)		22 ± 2	16 ± 2	<0.001*
ASA	II	13 (48.1%)	12 (44.4%)	0.785
	III	14 (51.9%)	15 (55.6%)	
Side	Right	14 (51.9%)	17 (63.0%)	0.409
	Left	13 (48.1%)	10 (37.0%)	
Patient Satisfaction	1	20 (74.1%)	22 (81.5%)	0.513
	2	7 (25.9%)	5 (18.5%)	
Outcome	Success	21 (77.8%)	23 (85.2%)	0.484
	Failure	6 (22.2%)	4 (14.8%)	
Reduction of VAS ≥ 50% after 24 w		21 (77.8%)	23 (85.2%)	0.484

Data are presented as mean ± SD or number (%).
*P-value < 0.05 is considered statistically significant.

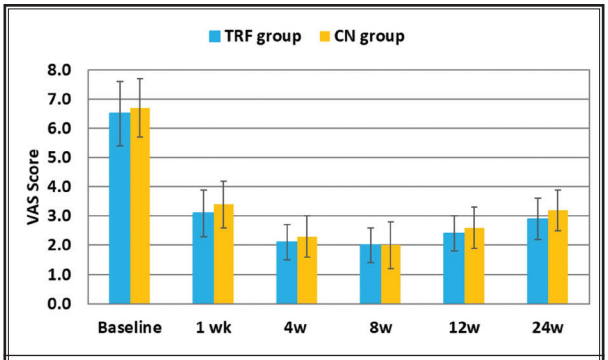

Fig. 3. *Pre-procedural and post-procedural VAS scores throughout the trial period.*

groups had respective PIs of 4.5 ± 0.6 and 4.5 ± 0.8 (Table 2).

Changes in the Temperature of the Affected Upper Limbs After the Thoracic Sympathetic Blocks

As with the PIs, the range of pre-procedural temperatures in the affected limbs of the TRF group (31.1 ± 0.7) was not significantly different from that seen in the neurolytic group (31.2 ± 0.8). Additionally, the temperature values were comparable after 5 (34.3 ± 1.8

Table 2. *Pre- and post-procedural PI and temperature and changes.*

	TRF Group (n = 27)	Neurolysis Group (n = 27)	*P*-value
Perfusion Index			
Normal	3.6 ± 0.6	3.7 ± 0.6	0.803
Affected Side Before	1.5 ± 0.5	1.5 ± 0.3	0.498
Affected Side After 5 min.	5.3 ± 0.7	5.9 ± 0.9	0.008*
Affected Side After 20 min.	6.0 ± 0.4	6.2 ± 0.8	0.256
Change After 5 min.	3.9 ± 0.8	4.4 ± 0.9	0.044*
Change After 20 min.	4.5 ± 0.6	4.5 ± 0.8	0.971
Temperature (° C)			
Normal	33.4 ± 0.6	33.5 ± 0.7	0.741
Affected Side Before	31.1 ± 0.7	31.2 ± 0.8	0.688
Affected Side After 5 min.	34.3 ± 1.8	34.4 ± 0.6	0.708
Affected Side After 20 min.	34.7 ± 0.6	34.6 ± 0.7	0.202
Change After 5 min.	3.6 ± 1.1	3.2 ± 0.9	0.255
Change After 20 min.	3.7 ± 1.1	3.4 ± 0.9	0.268

Data are presented as mean ± SD.
*P-value < 0.05 is considered statistically significant.

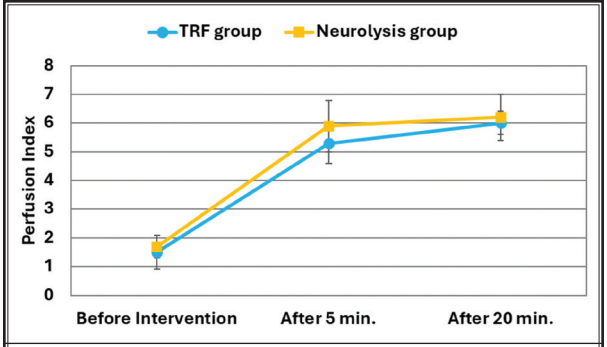

Fig. 4. *Pre- and post-procedural PIs of the affected sides.*

vs. 34.4± 0.6, P = 0.708) and 20 minutes (34.7 ± 0.6 vs. 34.6 ± 0.7, P = 0.202) for the TRF and neurolysis groups, respectively (Table 2) (Fig. 5). The changes in the affected limbs' temperatures before the procedure and at 5 and 20 minutes after it were also comparable for both groups.) In the TRF group, the pre-procedural and post-procedural ranges were 3.6 ± 1.1 and 3.2 ± 0.9, respectively, and those in the neurolysis group were 3.7 ± 1.1 before the procedure and 3.4 ± 0.9 afterward (Table 2).

Both groups were also comparable in the type of surgery and areas of pain distribution (Table 3).

Analgesic consumption for both groups was calculated based on the average consumption over the 3 days preceding each visit throughout the trial time. Drug consumption was comparable for both groups before and after the procedure (Table 4). Compared to the baseline, the doses of oxycodone and pregabalin patients consumed decreased significantly for the 2 groups at 24 weeks after the procedure (P < 0.001, for all comparisons).

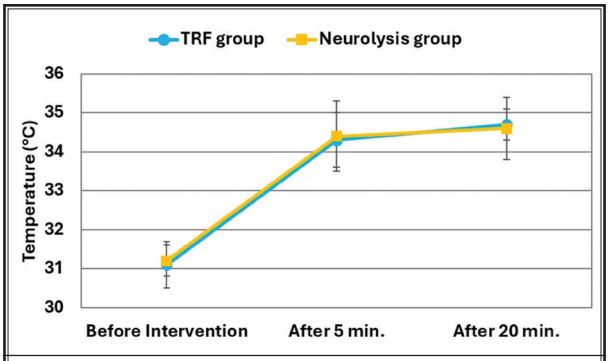

Fig. 5. *Pre- and post-procedural temperature changes in the affected sides.*

The incidence of breakthrough pain attacks was comparable for both groups through the trial time, with in post-procedural incidence reduced significantly from pre-procedural incidence (Table 4).

QoL scores were comparable for both groups before and after the procedure, with the post-procedural scores showing significant improvement from the baseline. Compared to the baseline, the QoL scores in the physical domain increased significantly in the TRF group at the 24-week mark (P < 0.001 for all comparisons except the difference between the 24-week and baseline scores [P = 0.008]). The physical-domain QoL scores also increased significantly in the neurolysis group at the 12-week point (P < 0.001 for all comparisons except the difference between the 12-week and baseline scores [P = 0.001]) (Table 5).

In the TRF group, the mental-domain QoL scores increased significantly from the baseline to the 12-week mark (P < 0.001 for all comparisons except the difference between the 12-week and baseline scores [P = 0.015]). Similarly, the mental-domain QoL scores increased significantly in the neurolysis group at 24 weeks after the procedure (P = 0.001, P < 0.001, P < 0.001, P = 0.002, and P = 0.036 for the 5 comparisons, respectively) (Table 5).

Both TRF and chemical neurolysis were well tolerated, with no major adverse events reported. Minor complications included transient local pain at the injec-

Table 3. *Type of surgery and area of pain distribution.*

	TRF Group (n = 27)	Neurolysis Group (n = 27)	Total	*P*-value
Type of Surgery				
MRM	16 (59.3%)	17 (63.0%)	33 (61.1%)	1.000
Conservative mastectomy	8 (29.6%)	8 (29.6%)	16 (29.6%)	
Reconstructive surgery	3 (11.1%)	2 (7.4%)	5 (9.3%)	
Area of Pain Distribution				
Ipsilateral upper arm	19 (70.4%)	17 (63.0%)	36 (66.7%)	0.849
Ipsilateral armpit	5 (18.5%)	6 (22.2%)	11 (20.4%)	
Breast area	3 (11.1%)	4 (14.8%)	7 (13.0%)	

Data are presented as number (%).

tion site in 4 patients (14.8%) in the TRF group and 6 patients (22%) in the neurolysis group. Post-procedural neuralgia occurred in 2 patients (7.4%) in the neurolysis group, while no such cases were observed in the TRF group. No incidences of pneumothorax, lung injuries, or significant motor weakness were recorded in either group (Table 6).

Discussion

The assessment of pain is subjective and depends on multiple variables, including physiological, emotional, and cognitive factors (16). Thus, in addition to the patient's subjective pain reporting, a reliable objective tool is needed for the accurate assessment of the results of any pain intervention modality. Temperature changes have been used to evaluate the effectiveness of sympathetic blocks for extremities. Although increases in temperature have been used to confirm sympathetic blocks, such increases have also been reported to take place with partial blocks, so temperature cannot be used as a reliable objective tool (12).

Our results demonstrated that between the 2 groups, the range of pre-procedural temperature and PI of the affected limbs showed no significant difference. Additionally, the post-procedural increase in temperature was comparable for both groups at the 5- and 20- minute marks. During the first 5 minutes of the block, chemical neurolysis caused an immediate rise in the affected limb's PI, making it significantly higher than that seen in the TRF block; both groups showed comparable PI changes after 20 minutes, however.

Table 4. *Analgesic consumption and incidence of breakthrough pain before and after the procedure in the 2 groups.*

	TRF Group (n = 27)	Neurolysis Group (n = 27)	*P*-value
Analgesic Drug Consumption	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Oxycodone			
Baseline	73 ± 13	76 ± 13	0.373
One w	37 ± 8	36 ± 9	0.518
4 w	27 ± 7	24 ± 8	0.308
8 w	25 ± 5	23±6	0.231
12 w	29 ± 6	28 ± 6	0.506
24 w	37 ± 7	36 ± 7	0.701
Pregabalin			
Baseline	344 ± 39	349 ± 36	0.653
One w	170 ± 18	168 ± 21	0.603
4 w	136 ± 23	132 ± 23	0.558
8 w	119 ± 15	115 ± 16	0.381
12 w	131 ± 14	128 ± 16	0.506
24 w	169 ± 19	166 ± 22	0.510
Incidence of Breakthrough Pain Attacks/ Day	**Median (Range)**	**Median (Range)**	**Median (Range)**
Baseline	3 (2-5)	3 (2-5)	1.000
2 w	2 (1-2)	2 (1-3)	0.556
4 w	2 (1-2)	1 (1-2)	0.278
8 w	1 (1-2)	1 (1-3)	0.643
12 w	1 (1-3)	1 (1-3)	0.100
24 w	2 (1-3)	2 (1-3)	0.694

Data are presented as mean±SD, median (range)

In 2009, Ginosar et al (17) presented PI as a reliable tool for the confirmation of sympathetic blocks after epidural anesthesia. They reported that PI could be considered an earlier, more sensitive indicator for sympathetic blocks than changes in temperature and arterial blood pressure. The PI is an instant noninvasive monitoring method that displays the pulse wave recorded from alterations to light transmission that follow changes in the body tissues' blood flow (18). The derived values of PI depend on both macro- and microcirculation; however, these values show a wide range of individual variations (18). Therefore, in the current trial, the PI values of each patient's unaffected and affected sides were recorded before the procedure, as were the

Table 5. *QoL scores for the 2 groups throughout the trial period.*

QoL Score (SF-36)	TRF Group (n = 27)	Neurolysis Group (n = 27)	*P*-value
Physical Domain			
Baseline	60 ± 10	59 ± 12	0.854
2 w	67 ± 7	69 ± 6	0.226
4 w	71 ± 6	73 ± 5	0.060
8 w	73 ± 6	75 ± 5	0.104
12 w	69 ± 5	70 ± 5	0.510
24 w	65 ± 5	66 ± 6	0.836
Mental Domain			
Baseline	67 ± 9	62 ± 13	0.059
2 w	71 ± 7	68 ± 10	0.193
4 w	73 ± 7	71 ± 9	0.490
8 w	73 ± 7	73 ± 8	0.939
12 w	71 ± 6	70 ± 7	0.438
24 w	68 ± 5	67 ± 7	0.716

Data are presented as mean ± SD.

Table 6. *Complications related to the techniques.*

Complication	TRF Group (n = 27)	Neurolysis Group (n = 27)	*P*-value
Transient Local Pain	4 (14.8%)	6 (22%)	0.728
Post-Procedural Neuralgia	0 (0%)	2 (7.4%)	0.491
Pneumothorax	0 (0%)	0 (0%)	N/A
Lung Injury	0 (0%)	0 (0%)	N/A
Motor Weakness	0 (0%)	0 (0%)	N/A

Data are presented as number (%).

affected side's PI values at 5 and 20 minutes after it. The objective changes in the PI measurements were associated with the patients' clinical improvement, including reduction in VAS scores and analgesic consumption and improvement in the patients' QoL. Accordingly, the current trial demonstrated that both TRF and neurolysis result in effective blocks, with the RF procedure potentially involving lower complications but a longer duration. Inaccurate positioning or spreading of neurolytic materials in this rich vascular and nervous area carries a risk of great hazards with catastrophic complications (19). A meta-analysis was conducted to investigate the diagnostic accuracy of PI and PI ratio as a predictor of nerve block failure. The trial reported that PI had a 77% sensitivity and 88.1% specificity while the PI ratio showed a sensitivity of 82.9% and a specificity of 93.1%. Thus, those researchers assumed that both the PI and PI ratio could serve as a useful tool for the assessment of nerve block efficacy in routine practice (20). The PI was also used to evaluate the effectiveness and success of caudal block in a group of pediatric patients. A study conducted by Elfeil et al (21) reported that PI was a simple, noninvasive tool that could be considered an effective predictor for assessing the results of caudal blocks.

In 2018, Yamazaki et al (7) published a retrospective survey of 30 patients who underwent SGBs. The researchers assessed block efficacy through clinical signs, such as the presence of Horner syndrome, vasodilatation, and hypohidrosis, in addition to PI changes in the ear lobe and upper limb. For 21 patients, Yamazaki et al reported a positive correlation between clinical improvement and increase in PI measurements, concluding that the PI could be considered a reliable indicator of the success of a block.

A case series was conducted on 4 patients who underwent T2 and T3 TRF for 60 seconds at 80° C to manage complex regional pain syndrome (CRPS) that did not respond to a stellate block. The series results reported that T2 and T3 TRF could be applied effectively as a part of a multimodal approach for patients who had CRPS after brachial plexus injury, based on a documented reduction in patients' analgesic requirements up to a period of 6 months (22). Furthermore, in a study carried out to compare T2 and T3 TRF to chemical neurolysis that used 0.5 mL alcohol at the T2 level for patients with Raynaud's disease, it was observed that both techniques had comparable analgesic effects, with a shorter procedure duration for the single-level neurolysis (23). A 2023 retrospective study conducted by Xin et al (19) examined the difference between thoracic sympathetic nerve blocks used with chemical neurolysis to those used with TRF in patients with Raynaud's disease. The chemical-neurolysis group received 2.5 mL of alcohol while the RF group underwent TRF consisting of 2 cycles of 300 seconds' duration at 95°C. The study reported comparable results, though the patients who received TRF had a better QoL. Additionally, the results demonstrated a significant increase from the pre-procedural values of the measured temperature and PI to the post-procedural values (19).

Hetta et al investigated the analgesic efficacy of TRF on the thoracic sympathetic nerves of patients with PMPS. Their results showed that a 120-second TRF session of T2, T3, and T4 at 80°C resulted in lower pain scores, less consumption of analgesics and anti-neu-

ropathic agents, and a better QoL than did the sham block (15).

The efficacy of thoracic sympathetic RF was compared to that of ethanol neurolysis for patients suffering from hyperhidrosis, showing that although a 120-second session of TRF at 90°C was associated with longer duration and technical difficulties, that procedure demonstrated longer-lasting effects. However, the chemical neurolysis, which used 4 mL of ethanol 90%, resulted in an immediate intense block, with a risk of complications due to possible liquid spread (24). The risk of complications in the study conducted by Hetta el al (15) might be related to the relatively large volume of ethanol used.

Another study of hyperhidrosis management reported that patients who underwent a 300-second session of TRF at 95°C had fewer incidences of intercostal neuralgia and a longer-lasting block effect than did patients who received a thoracic sympathetic block in the form of chemical neurolysis with 2.5 mL of absolute alcohol (25).

Phenol neurolysis serves as a viable alternative to TRF when the latter is unavailable, offering an effective sympathetic blockade for treating PMPS. While TRF delivers a controlled and precise nerve lesion with fewer complications, phenol injections can provide comparable pain relief by chemically disrupting nerve function. However, a phenol injection carries a greater risk of uncontrolled spread, vascular absorption, and potential neurotoxicity, necessitating careful injection techniques to minimize adverse effects. In resource-constrained environments where TRF equipment is inaccessible, phenol remains a practical and economical option for sympathetic neurolysis, provided that imaging guidance and skilled expertise are employed.

The findings of this trial demonstrate the clinical relevance of choosing the appropriate technique for T2 and T3 sympathectomy in managing PMPS. While both TRF and chemical neurolysis demonstrated significant pain reduction, TRF showed a lower complication rate, making it a safer option in experienced hands. However, chemical neurolysis was associated with a more immediate increase in the PI, which may be beneficial in cases requiring rapid sympathetic blockades. These results emphasize the importance of patient selection when deciding between the 2 techniques, particularly in settings where TRF equipment is unavailable. Additionally, the trial reinforces the utility of PI as an objective, noninvasive measure for assessing sympathetic block efficacy, which could improve real-time clinical decision-making. Future research with larger sample sizes and extended follow-up is required to further refine treatment guidelines.

Limitations

The current trial took place at a single center and was limited to one category of patients who were diagnosed with PMPS. Results may vary in nonmalignant patients with shorter disease durations. Additionally, the sample size was relatively small, owing to the specific inclusion criteria.

Conclusion

Both TRF and chemical neurolysis are effective for T2 and T3 sympathectomy in the management of PMPS. Although neurolysis provides faster PI changes, TRF can offer a potentially safer profile. The PI can serve as a reliable tool for the assessment of T2 and T3 sympathetic blocks.

References

1. Couceiro TCDM, de Menezes TC, Valênça MM. Síndrome dolorosa pós-mastectomia. A magnitude do problema. *Rev Bras Anestesiol* 2009; 59:358-365.
2. Macdonald L, Bruce J, Scott NW, Smith WCS, Chambers WA. Long-term follow-up of breast cancer survivors with post-mastectomy pain syndrome. *Br J Cancer* 2005; 92:225-230.
3. Wood KM. Intercostobrachial nerve entrapment syndrome. *South Med J* 1978; 71:662-663.
4. Yuksel SS, Chappell AG, Jackson BT, Wescott AB, Ellis MF. Post-mastectomy pain syndrome: A systematic review of prevention modalities. *JPRAS Open* 2022; 31:32-49.
5. Kehlet H, Jensen TS, Woolf CJ. Persistent postsurgical pain: Risk factors and prevention. *Lancet* 2006; 367:1618-1625.
6. Zhang JM and Chen SS. Progress in sympathetically mediated pathological pain. *J Anesth Perioper Med* 2017; 176:216-225.
7. Yamazaki H, Nishiyama J, Suzuki T. Use of perfusion index from pulse oximetry to determine efficacy of stellate ganglion block. *Local Reg Anesth* 2012; 5:9-14.
8. Nabil Abbas D, Abd El Ghafar EM, Ibrahim WA, Omran AF. Fluoroscopic stellate ganglion block for postmastectomy pain: A comparison of the classic anterior approach and the oblique approach. *Clin J Pain* 2011; 27:207-213.
9. Kuntz A. Distribution of the sympathetic rami to the brachial plexus: Its relation to sympathectomy affecting the upper extremity. *Arch Surg* 1927; 15:871-877.
10. Skaebuland C, Racz G. Indications and

technique of thoracic(2) and thoracic(3) neurolysis. *Curr Rev Pain* 1999; 3:400-405.

11. Yoo HS, Nahm FS, Lee PB, Lee CJ. Early thoracic sympathetic block improves the treatment effect for upper extremity neuropathic pain. *Anesth Analg* 2011; 113:605-609.
12. Erdine S. Neurolytic blocks: When, how, why. *Agri* 2009 Oct; 21:133-140.
13. Zacharias NA, Karri J, Garcia C, Lachman LK, Abd-Elsayed A. Interventional radiofrequency treatment for the sympathetic nervous system: A review article. *Pain Ther* 2021; 10:115-141.
14. McHorney CA, Ware JE Jr, Raczek A. The MOS 36-Item Short-Form Health Survey (SF-36). *Med Care* 1993; 31:247-263.
15. Hetta DF, Mohamed AA, Hetta HF, et al. Radiofrequency thoracic sympathectomy for sympathetically maintained chronic post-mastectomy pain, a preliminary report: 6-month results. *Pain Pract* 2021; 21:54-63.
16. Love-Jones SJ. Pain as a subjective, multidimensional experience. In: Abd-Elsayed A (ed). *Pain: A Review Guide,* Springer Cham, 2019, pp 141-144.
17. Ginosar Y, Weiniger CF, Meroz Y, et al. Pulse oximeter perfusion index as an early indicator of sympathectomy after epidural anesthesia. *Acta Anaesthesiol Scand* 2009; 53:1018-1026.
18. Sun X, He H, Xu M, Long Y. Peripheral perfusion index of pulse oximetry in adult patients: A narrative review. *Eur J Med Res* 2024; 29:457.
19. Xin B, Xie K, Huang B, Yao M. Efficacy of radiofrequency thermocoagulation of the thoracic sympathetic nerve versus chemical excision in pain caused by Raynaud's disease. *J Pain Res* 2023; 16:649-658.
20. Hung KC, Liu CC, Huang YT, et al. The efficacy of Perfusion Index for identifying failed nerve block in patients receiving upper extremity surgery: A meta-analysis. *Minerva Anestesiol* 2024; 90:311-320.
21. Essam Elfeil Y, Zarad AR, Deghidy EA. Comparison of two different methods as reliable predictors of successful caudal block in children. *Egypt J Anaesth* 2024; 40:69-74.
22. Chen CK, Phui VE, Nizar AJ, Yeo SN. Percutaneous T2 and T3 radiofrequency sympathectomy for complex regional pain syndrome secondary to brachial plexus injury: A case series. *Korean J Pain* 2013; 26:401-405.
23. Gabrhelik T, Michalek P, Adamus M, Berta E. Percutaneous upper thoracic radiofrequency sympathectomy in Raynaud phenomenon a comparison of T2/T3 procedure versus 12 lesion with phenol application. *Reg Anesth Pain Med* 2009; 34:425-429.
24. He Q, Zhu J, Luo G, et al. Efficacy of percutaneous radiofrequency sympathectomy versus percutaneous ethanol sympatholysis in the treatment of primary hyperhidrosis. *Pain Physician* 2022; 25:E689-E695.
25. Zhang L, Xu SS, Liu XL, Zhao W, Ma Y, Huang B. Comparison of CT-guided thoracic sympathetic nerve block and radiofrequency in the treatment of primary palmar hyperhidrosis. *Front Surg* 2023; 10:1126596..