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Radiofrequency neurolysis of the paravertebral sympathetic chain: a single-centre retrospective analysis

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ABSTRACT

INTRODUCTION: Lumbar sympathectomy has historically been a widely used technique in vascular surgery. The advent of minimally invasive approaches capable of definitively interrupting the sympathetic chain at different levels may renew interest in sympathectomy, broadening its scope beyond current indications. This renewed interest could extend its potential benefits to conditions where open surgery is not commonly performed nowadays. This study aims to evaluate the efficacy and safety of radiofrequency neurolysis of the paravertebral sympathetic chain across a range of clinical conditions.

METHODS: This is a retrospective, single-centre study that included patients who underwent sympathetic chain interruption using percutaneous radiofrequency ablation under local anaesthesia between September 2022 and February 2024. The procedures targeted either the lumbar or the thoracic levels. The indications for the procedure were obstructive arterial disease, complex regional pain syndrome and primary focal hyperhidrosis. Patients underwent re-evaluated during follow-up appointments aimed at monitoring the benefits, complications and adverse effects of surgery.

RESULTS: This cohort comprises 23 patients, of whom 83% are female. The average age of the patients is 46.9 ± 17.4 years. The primary indications for lumbar radiofrequency neurolysis of the paravertebral sympathetic chain are plantar hyperhidrosis (n = 8, 35%) and rest ischemic pain (n = 7, 30%). During this period, 49 procedures were performed, with 39 of them at the lumbar level. Most of the patients underwent bilateral procedures (53%). More than 88% of procedures result in clinical improvement for patients, with complete resolution occurring in around 35% of cases. Lumbar radiofrequency neurolysis is associated with no complications.

CONCLUSION: Lumbar radiofrequency neurolysis of the paravertebral sympathetic chain presents as a minimally invasive and safe alternative approach to abolishing sympathetic tone, although it is currently less effective than open surgery. It may potentially be applied to patients formally indicated for lumbar sympathectomy.

Keywords: Hyperhidrosis; Radiofrequency neurolysis; Sympathetic nervous system; Lumbar sympathectomy

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INTRODUCTION

The historical trajectory of surgical interventions on the sympathetic nervous system traces back to the late 19th century.[1] In the early 20th century, lumbar sympathectomy was at the forefront of treating peripheral arterial disease, vasospastic disorders and clinical situations involving visceral pain.[2,3] However, throughout the 20th century, the prominence of surgical lumbar sympathectomy waned significantly due to the emergence of direct revascularisation techniques, facilitated by technological advancements.

The advent of minimally invasive approaches has reignited interest in sympathectomy by offering precise sympathetic chain interruption at various levels. Chemical-mediated neurolysis, employing agents such as absolute alcohol or phenol, or thermal neurolysis using radiofrequency or laser ablation strategies, has recently been described.[4] Minimally invasive techniques offer advantages such as controlled lesion formation, low complication rates, and minimal perioperative discomfort.[5] The minimal invasive technique can prove beneficial as an additional pain-management strategy for ischaemic rest pain in patients unsuitable for revascularisation treatment or rest pain after vascular treatment, or replace open surgery in complex regional pain syndrome (CRPS), peripheral vasospasm, postherpetic neuralgia, or phantom limb pain.[4,6] Furthermore, its efficacy in treating hyperhidrosis, however limited, has been documented with favourable outcomes and minimal morbidity.[7]

The objective of this study was to evaluate the clinical outcomes of radiofrequency neurolysis of the paravertebral sympathetic chain in patients at our institution presenting with some aforementioned clinical conditions.

METHODS

Cohort selection

This was a single-centre, retrospective observational cohort study, reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[8] Data were collected from patients who underwent sympathetic chain interruption using percutaneous radiofrequency under local anaesthesia between September 2022 and February 2024, in a tertiary hospital. The procedures targeted both lumbar and thoracic levels of the sympathetic chain and could be performed unilaterally or bilaterally. All procedures were conducted on an outpatient basis. All procedures were performed by the same surgeon, who had extensive experience in surgical lumbar sympathectomy and video-assisted thoracoscopic sympathectomy. The use of fluoroscopy-guided interventions on the sympathetic chain was based on similar techniques employed in pain management. Patient follow-up was standardised, with assessments conducted pre- and post-intervention by the operating surgeon. Indications for the procedure included patients with peripheral obstructive arterial disease with uncontrolled rest pain after revascularisation procedures, complex regional pain syndrome, also known as causalgia, and primary focal hyperhidrosis, specifically plantar hyperhidrosis. Preoperative medical records, including comprehensive medical history and physical examination, operative reports, and anaesthesia records, were reviewed for each patient. Follow-up information was obtained from medical records.

Surgical technique

Patients were positioned prone on the operating table, with continuous monitoring of vital signs throughout the procedure. Preoperative foot temperatures were measured using a cutaneous thermometer placed on the hallux. The lumbar region was then sterilised, and local anaesthesia was administered to the paravertebral region to achieve analgesia. Fluoroscopy-guided puncture, including anteroposterior, oblique, and lateral projections, was employed to place the needle in the anterolateral vertebral region in anatomic proximity to the targeted lumbar sympathetic nerve, while ensuring avoidance of adjacent structures. Contrast injection was subsequently performed to confirm the needle in the extravascular space.

The radiofrequency ablation was performed using a 20-gauge radiofrequency needle (TOP Corporation, Tokyo, Japan) with a 10-mm active tip. Sensory (50Hz, 1V) and motor (2Hz, 3V) tests were conducted before proceeding with the ablation. Needle placement was re-adjusted if patients exhibited any sensory and/or motor symptoms compatible with dermatome or myotome innervated by respective sensory or motor nervous roots. In the absence of symptoms, the surgeon proceeds to lidocaine injection with the aim of anaesthetising deep and paravertebral tissues at the needle tip.

The ablation was set at 90°C for 90 seconds, using a radiofrequency generator Top Lesion Generator TLG-10 (TOP Corporation, Tokyo, Japan). In continuous radiofrequency thermo-ablation, a bipolar lesion field was applied, while in pulsed radiofrequency, a monopolar field was assumed. Following completion of the ablation, the needle was withdrawn, and a small bandage was applied to the skin. During the entire procedure, foot temperatures and/or regional perfusion were measured using a skin thermometer. Patients were monitored for 4 hours post-procedure before being discharged home.

Outcomes

The primary outcome measures were the 30-day post-procedure clinical outcomes of patients submitted to radiofrequency neurolysis. Clinical outcomes were categorized for patients with peripherical obstructive arterial disease with uncontrolled rest pain after revascularization procedures, complex regional pain syndrome and primary focal hyperhidrosis: 1) complete clinical improvement – complete absence of symptoms; 2) partial clinical improvement - improve of symptoms of clinical conditions; 3) relapse – include patients that experience symptoms again after a period of remission; 4) absence of clinical improvement – referred to patients that lacked of symptoms relief.

Statistical analysis

Categorical variables are expressed as number of cases and percentage (%), and the quantitative variables are expressed as mean and standard deviation. All statistical analyses were performed using IBM SPSS Statistics version 27 for Windows.

RESULTS

This study comprised a cohort of 23 patients, predominantly females (83%). The mean age of the patients was 46.9 ± 17.4 years. The indications for radiofrequency neurolysis of the lumbar level represent 78.3% of cases. The primary indications for radiofrequency neurolysis of the lumbar paravertebral sympathetic chain were plantar hyperhidrosis (34.9%), rest ischemic pain (30.5%), complex regional pain syndrome (4.3%), sympathetic dysautonomia (4.3%) and thromboangiitis obliterans (4.3%). Radiofrequency neurolysis of the thoracic paravertebral sympathetic chain was primarily indicated for palmar hyperhidrosis (17.4%) and refractory abdominal pain (4.3%), Table 1.

Table 1. Baseline characteristics and indications of patients submitted to radiofrequency neurolysis

N (% female)	23 (82.6)
Mean age - years ± SD [range]	46.9 ± 17.4 [20 - 87]
Indications for a thoracic procedure	
Palmar hyperhidrosis – N (% female)	4 (50)
Refractory abdominal pain – N (% female)	1 (100)
Indications for a lumbar procedure	
Plantar hyperhidrosis – N (% female)	8 (100)
Rest ischaemic pain – N (% female)	7 (71.4)
Complex regional pain syndrome – N (% female)	1 (100)
Sympathetic dysautonomia – N (% female)	1 (100)
Thromboangiitis obliterans – N (% female)	1 (100)

A total of 49 radiofrequency neurolysis procedures were performed during the study period, of which 39 (79.6%) were conducted at the lumbar level. Bilateral procedures were administered to the majority of patients (53.1%). Of the patients included in the study, 21.7% (n = 5) underwent repeat radiofrequency neurolysis interventions, Table 2.

Table 2. Procedural details of patients submitted to radiofrequency neurolysis

Number of procedures	49
Procedure laterality	
Unilateral – N (%)	15 (46.9)
Left – N (%)	7 (21.9)
Right – N (%)	8 (25.0)
Bilateral – N (%)	17 (53.1)
Procedure level	
Thoracic – N (%)	10 (20.4)
Lumbar – N (%)	39 (79.6)

Clinical improvement was observed in over 88% of patients after procedures (38/43), with complete resolution, partial resolution, and relapse achieved in 34.9%, 30.2%, and 23.3% of cases, respectively. Lumbar radiofrequency neurolysis was associated with no short-term complications. However, short-term complications were limited to thoracic procedures, with three cases of pneumothorax reported necessitating inpatient care and thoracic drainage, Table 3.

Table 3. Clinical outcomes of patients submitted to radiofrequency neurolysis

Patients evaluated in follow-up appointment – N (%)	19 (82.6)
Clinical outcomes after each procedure	
Clinical improvement – N (%)	38 (88.4)
Complete – N (%)	15 (34.9)
Partial – N (%)	13 (30.2)
Relapse – N (%)	10 (23.3)
No improvement – N (%)	5 (11.6)
30-day complications	
Thoracic procedure (n = 10) – N (%)	3 (30.0)
Pneumothorax – N (%)	3 (30.0)
Lumbar procedure (n = 39) – N (%)	0 (0)
30-day mortality – N (%)	0 (0)

One patient, who was experiencing persistent symptoms following a thoracic procedure, underwent a thoracoscopic sympathectomy with carbon dioxide. Additionally, another patient, who did not experience clinical improvement after lumbar radiofrequency treatment, underwent surgical lumbar sympathectomy.

Additionally, clinical improvement was analysed for the two most representative indications: plantar hyperhidrosis and peripheral obstructive arterial disease with uncontrolled rest pain following revascularisation. In both groups, approximately 85% of patients who underwent the procedure experienced clinical improvement. However, the rate of complete symptom resolution was higher in patients with peripheral arterial disease compared to those with plantar hyperhidrosis (57.1% vs. 14.3%, respectively, Table 4).

Table 4. Clinical outcomes of patients submitted to radiofrequency neurolysis, per indication

	Plantar hyperhidrosis (N = 7)	Rest ischaemic pain (N = 7)
Clinical improvement – N (%)	6 (85.7)	6 (85.7)
Complete – N (%)	1 (14.3)	4 (57.1)
Partial – N (%)	3 (42.8)	0 (0)
Relapse – N (%)	2 (28.6)	2 (28.6)
No improvement – N (%)	1 (14.3)	1 (14.3)

DISCUSSION

This study presents 23 patients undergoing radiofrequency neurolysis of the paravertebral sympathetic chain, aiming for a minimally invasive alternative to open sympathectomy. Accordingly, 49 radiofrequency neurolysis procedures were performed at the thoracic and lumbar levels. The findings demonstrate that lumbar radiofrequency neurolysis of the paravertebral sympathetic chain is a minimally invasive procedure with a low incidence of complications. In this cohort, over 88% of the procedures resulted in clinical improvements. When a sub-analysis cohort was performed, despite equal clinical improvement rates, patients with peripheral obstructive arterial disease and uncontrolled rest pain following revascularisation presented higher rates of complete clinical improvement compared to patients with plantar hyperhidrosis (57.1% vs. 14.3%, respectively).

Scientific reports in the literature on radiofrequency neurolysis of the paravertebral sympathetic chain primarily focus on sympathetically mediated pain, predominantly in conditions such as complex regional pain syndrome and rest ischaemic pain, and on its use for plantar hyperhidrosis is rare.[7,9-13] The clinical outcomes described in this study surpass those reported by Haynsworth and Noe, with a 12% sympathetic chain blockade eight weeks after the radiofrequency procedure.[14] Ding et al. compared the efficacy and safety of radiofrequency lumbar sympathectomy with chemical blockade in patients with painful diabetic peripheral neuropathy. They found that the total pain remission rate one year after the procedure was 73.3% in patients who underwent radiofrequency ablation. Additionally, they observed that combining radiofrequency with chemical blockade in the same procedure significantly improved pain relief. However, this combination also led to a statistically significant increase in numbness and hyperalgesia.[10] The combination of these data with the outpatient surgical procedure renders this surgical technique quite promising, potentially rivalling surgical sympathectomy in the future.

The use of this technique requires familiarity with fluoroscopy of the thoracic and lumbar vertebral osseous landmarks to increase efficacy and decrease possible complications. The optimal electrode positioning, as well as the radiofrequency protocol to be used, influences the results.[14] Several studies have reported similar results using computed tomography (CT) guidance. However, CT imaging is less accessible and is associated with higher radiation exposure[9,10] It is worth noting that the protocol used in this study was extrapolated from the protocol used in radiofrequency lesioning of other neural structures, given the limited references in the literature on this specific procedure.[11,13] Therefore, adaptation of the protocol may be considered based on this specific context of radiofrequency neurolysis of the paravertebral sympathetic chain, aiming to achieve satisfactory short and long-term results.

The early reappearance of symptoms poses a clinical challenge, necessitating the repetition of the procedure in some patients. In this study, around 21.7% of patients underwent a repeat radiofrequency neurolysis intervention. Reasons for the recurrence of symptoms in patients undergoing radiofrequency neurolysis may include possible anatomical variations of the sympathetic paravertebral chain, suboptimal positioning of the needle tip, and incomplete lesion induced by radiofrequency ablation. The effect of electrode size, lesion halo, duration of the lesion, adoption of monopolar or bipolar lesions, and target tissue temperature are variables that can affect the success of the radiofrequency neurolysis.[15]

This study presents several limitations that must be considered. Firstly, it is an observational, single-centre, single-operator, retrospective study, which introduces potential biases and limits the size of the dataset available for analysis. Secondly, the inclusion of various clinical conditions and the broad interpretation of the results may further constrain their applicability. Future research should aim to validate these findings in diverse and larger patient cohorts to enhance the robustness and generalizability of the conclusions.

CONCLUSION

Radiofrequency neurolysis of the lumbar paravertebral sympathetic chain is a safe, effective, and durable method for abolishing sympathetic tone. It can be applied in patients with a formal indication for lumbar sympathectomy, but using a minimally invasive approach. The data described configure this technique as promising for the treatment of plantar hyperhidrosis; however, it is necessary to conduct larger, multi-centre studies to validate the efficiency and safety of this technique across diverse populations.

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