

CT-Guided Lumbar Sympathetic Neurolysis for Ischemic Rest Pain in Chronic Limb Threatening Ischemia: Clinical Outcomes and Immediate Doppler Hemodynamic Changes in a Single-Center Cohort

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Abstract

Background: Chronic limb-threatening ischemia (CLTI) represents the most severe clinical manifestation of peripheral arterial disease and is associated with severe ischemic rest pain, tissue loss, amputation, and impaired quality of life. In selected patients with persistent ischemic pain, lumbar sympathetic neurolysis may provide symptomatic relief through interruption of sympathetic vasoconstrictor activity and sympathetically mediated pain pathways. **Purpose:** To evaluate the clinical efficacy, technical outcomes, safety profile, and immediate Doppler hemodynamic changes following CT-guided lumbar sympathetic neurolysis in patients with CLTI presenting with ischemic rest pain. **Materials and Methods:** This single-center observational cohort study included 25 patients with peripheral arterial disease and Fontaine stage III or IV CLTI who underwent CT-guided lumbar sympathetic neurolysis for ischemic rest pain. The lumbar sympathetic region was targeted at the L2, L3, and L4 levels using a standardized CT-guided technique and a neurolytic protocol comprising triamcinolone acetonide with contrast confirmation, 0.25% ropivacaine, and absolute alcohol. Pain severity was assessed using the Numeric Rating Scale (NRS) at baseline, immediately after the procedure, 24 hours, 1 week, 1 month, and 3 months. Doppler-derived resistive index (RI) of the dorsalis pedis artery was measured immediately before and after the procedure. Technical success, immediate sympathetic response, complications, and amputation outcomes were recorded. **Results:** Twenty-five patients were included, with a mean age of 59.1 ± 9.3 years; 22 patients (88%) were male. Fourteen patients (56%) had Fontaine stage III disease and 11 (44%) had Fontaine stage IV disease. Technical success and immediate sympathetic response were documented in all patients. Mean NRS decreased from 9.60 at baseline to 3.40 immediately after neurolysis, 2.80 at 24 hours, 2.04 at 1 week, 1.56 at 1 month, and 1.12 at 3 months. Pain scores demonstrated significant reduction across follow-up ($p < 0.001$). All patients achieved at least a 50% reduction in pain, and 11 patients (44%) achieved complete pain relief at the last available follow-up. Mean dorsalis pedis artery RI decreased from 0.654 ± 0.042 before the procedure to 0.569 ± 0.029 immediately after neurolysis ($p < 0.001$). Patients with Fontaine stage III disease demonstrated greater pain reduction than patients with Fontaine stage IV disease. Four patients experienced recorded complications. Six patients subsequently underwent minor toe amputation for gangrenous tissue present before neurolysis. No major amputations or deaths occurred during the available follow-up. **Conclusion:** CT-guided lumbar sympathetic neurolysis was associated with substantial and sustained reduction in ischemic rest pain and a significant immediate reduction in dorsalis pedis artery RI in this cohort of patients with CLTI. The procedure demonstrated a high technical success rate and may represent a symptom-directed treatment option in appropriately selected patients.

Keywords: Chronic limb-threatening ischemia; peripheral arterial disease; lumbar sympathectomy; lumbar sympathetic neurolysis; CT-guided intervention; ischemic rest pain; chemical neurolysis.

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Introduction

Chronic limb-threatening ischemia (CLTI) represents the most advanced clinical manifestation of peripheral arterial disease (PAD) and is associated with ischemic rest pain, tissue loss, amputation, impaired quality of life, and increased mortality. Contemporary Global Vascular Guidelines define CLTI as PAD in combination with ischemic rest pain, gangrene, or lower-limb ulceration of more than two weeks' duration.¹

Revascularization remains the preferred treatment strategy whenever technically and clinically feasible. However, some patients have diffuse distal arterial

disease, poor distal targets, severe comorbidities, failed previous revascularization, or persistent symptoms despite vascular treatment. In such patients, symptom-directed interventions may have an important role.

Lumbar sympathectomy produces interruption of sympathetic innervation to the lower limb and has historically been used for severe ischemic pain. Proposed mechanisms include reduction of sympathetic vasoconstrictor tone, vasodilatation of the peripheral circulation, alteration of collateral and cutaneous blood

CT-Guided Lumbar Sympathetic Neurolysis for Ischemic Rest Pain in Chronic Limb Threatening Ischemia: Clinical Outcomes and Immediate Doppler Hemodynamic Changes in a Single-Center Cohort

flow, and interruption of sympathetically mediated pain pathways.^{2,3}

Lumbar sympathectomy can be performed surgically or through percutaneous chemical neurolysis. CT guidance provides excellent visualization of vertebral anatomy, the psoas muscle, retroperitoneal structures, major vessels, and the planned needle trajectory. Furthermore, CT enables confirmation of the distribution of the neurolytic agent. Chahal *et al.* demonstrated that the direction of neurolytic agent spread may significantly influence long-term clinical outcomes following CT-guided lumbar sympathectomy.⁴

Despite its historical use, the evidence supporting lumbar sympathectomy in CLTI remains limited, with a lack of contemporary randomized controlled trials.³ Nevertheless, observational studies suggest that CT-guided chemical lumbar sympathectomy may provide meaningful relief of ischemic rest pain in selected patients.⁴

The present study aimed to evaluate the clinical outcomes, serial pain response, technical success, safety profile, and immediate Doppler-derived hemodynamic changes following CT-guided lumbar sympathetic neurolysis in patients with CLTI presenting with ischemic rest pain.

Materials and Methods

Study Design and Patient Population

This was a single-center observational cohort study including patients who underwent CT-guided lumbar sympathetic neurolysis for ischemic rest pain secondary to PAD.

A total of 25 patients were included.

All patients had CLTI and were classified clinically as Fontaine stage III or Fontaine stage IV.

Inclusion Criteria

Patients were included if they fulfilled the following criteria:

1. Peripheral arterial disease with CLTI.
2. Ischemic rest pain.
3. Fontaine stage III or Fontaine stage IV disease.
4. Underwent CT-guided lumbar sympathetic neurolysis.
5. Availability of baseline pain assessment.
6. Availability of post-procedure clinical follow-up data.

Exclusion Criteria

Patients were excluded if they had:

1. A predominant nonvascular cause of lower-limb pain.
2. Incomplete procedural documentation.
3. Absence of baseline pain assessment.
4. Lumbar sympathetic intervention performed for an indication other than ischemic limb pain.

Baseline Clinical Assessment

The following demographic and clinical variables were recorded:

- Age

- Sex
- Diabetes mellitus
- Hypertension
- Smoking status
- Coronary artery disease
- Chronic kidney disease
- Fontaine classification
- Presence of ulceration
- Presence of gangrene

CT-Guided Lumbar Sympathetic Neurolysis Technique

All procedures were performed under CT guidance using a standardized technique. Patients were positioned prone on the CT table.

Pre-procedural CT Planning

A baseline lumbar CT scan was obtained with the patient in the prone position. Multiplanar CT reconstructions were reviewed for procedural planning.

On sagittal reformatted images, the L2, L3, and L4 vertebral levels were first identified. The corresponding axial CT section at each level was subsequently selected for procedural planning. On each selected axial image, the intended target anterior to the psoas muscle was identified. A tangential line was drawn from the planned target toward the ipsilateral paraspinal region. A second reference line was drawn from the spinous process to intersect the previously planned tangential trajectory. The distances of these reference lines were measured and recorded for translation of the CT planning measurements onto the patient's skin.

Patients were specifically instructed not to move after CT planning until completion of the external skin markings. This was done to minimize positional discrepancies between CT-based planning and needle placement.



Fig 1: planning on CT with axial and sagittal reformatted images. At the level of L4 measurements are taken on axial image as shown

Skin Marking

Following completion of CT planning, the CT laser positioning system was used to identify and mark the axial levels corresponding to L2, L3, and L4 on the patient's back.

The spinous process at each corresponding level was palpated and marked manually using a skin marker. Using a measuring scale, the predetermined distance obtained from the planning CT was subsequently measured from the spinous process toward the side of the planned intervention.

CT-Guided Lumbar Sympathetic Neurolysis for Ischemic Rest Pain in Chronic Limb-Threatening Ischemia: Clinical Outcomes and Immediate Doppler Hemodynamic Changes in a Single-Center Cohort

The planned needle entry site and tangential trajectory were thereby transferred onto the skin according to the CT planning measurements and procedural laterality.

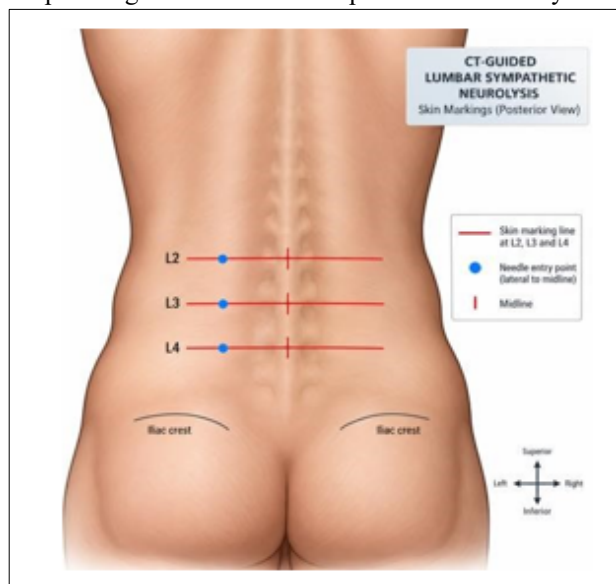


Fig 2: schematic representation of skin markings for needle entry.

Sterile Preparation and Needle Placement

After completion of the skin markings, the procedural field was prepared and draped under strict aseptic precautions. Local anesthesia was infiltrated at the planned skin entry sites. A 21-G Chiba needle was used in all patients. The needle was introduced along the predetermined tangential trajectory and initially advanced approximately 4–5 cm.

An interim CT scan was obtained to assess:

- Needle position
- Direction of the needle trajectory
- Relationship of the needle to the psoas muscle
- Alignment toward the intended lumbar sympathetic target

The needle direction was modified whenever required based on the interim CT findings. The needle was subsequently advanced in a controlled manner until its tip was positioned anterior to the psoas muscle and directed medially toward the expected location of the lumbar sympathetic plexus.

The same procedure was performed at the L2, L3, and L4 levels.

Once satisfactory needle positioning was achieved, a final CT scan was obtained to confirm the position of all needle tips.

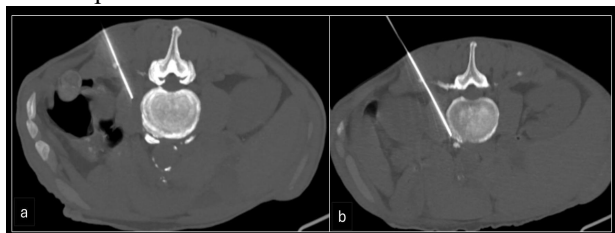


Fig3: a) 21G Chiba needle introduced along the planned trajectory at L3 level. Needle tip is in left psoas muscle. b) The needle is further advanced and needle tip is placed anterior to the psoas muscle.

Confirmation of Injectate Distribution

Following confirmation of satisfactory needle-tip position, 1 mL of triamcinolone acetonide (Kenacort) mixed with a small amount of iodinated contrast material was injected at each targeted level. CT imaging was subsequently used to assess the distribution of the injectate.

The neurolytic injection was administered only after satisfactory spread along the expected course of the lumbar sympathetic plexus was confirmed.

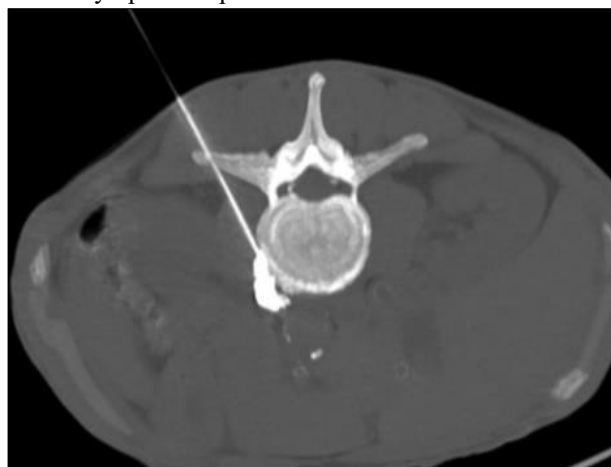


Fig4: a mixture of 1ml triamcinolone acetonide and contrast is injected to confirm the spread of injectate

Standardized Neurolytic Injection Protocol
The drug administration sequence was standardized and identical in all patients and at each targeted lumbar level. Following confirmation of satisfactory injectate distribution, 7 mL of 0.25% ropivacaine was administered at each targeted level. This was followed by injection of absolute alcohol as the neurolytic agent. The volume of absolute alcohol administered at each level depended on the side of intervention:

- Left-sided procedures: 15 mL of absolute alcohol at each level.
- Right-sided procedures: 10 mL of absolute alcohol at each level.

Following administration of absolute alcohol, an additional 3 mL of 0.25% ropivacaine was injected to clear the dead space of the 21-G Chiba needle and deliver the remaining injectate into the target region. Thus, a total volume of 10 mL of 0.25% ropivacaine was administered at each targeted level.

The same injection sequence was followed at all three targeted levels: L2, L3, and L4.

Accordingly, the total volume of 0.25% ropivacaine administered per procedure was 30 mL.

The total volume of absolute alcohol administered per procedure was:

- 45 mL for left-sided procedures.
- 30 mL for right-sided procedures.

CT-Guided Lumbar Sympathetic Neurolysis for Ischemic Rest Pain in Chronic Limb-Threatening Ischemia: Clinical Outcomes and Immediate Doppler Hemodynamic Changes in a Single-Center Cohort

Post-procedural CT Assessment

Following completion of the injections, the needles were removed and sterile dressings were applied.

A final post-procedural CT scan was obtained to:

1. Assess the distribution of the injected agents.
2. Confirm satisfactory spread along the expected lumbar sympathetic region.
3. Identify any immediate procedure-related complications.

Patients were subsequently observed clinically following the procedure.

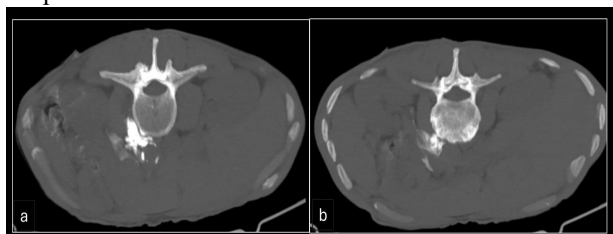


Fig5: a) predominantly medial spread of injectate. b) medial and lateral spread of injectate.

Outcome Assessment

NRS was recorded at baseline, immediately, 24 hours, 1 week, 1 month, and 3 months. Dorsalis pedis artery RI was measured immediately before and after neurolysis. Technical success required satisfactory target placement, injectate distribution, and completion of planned neurolysis.

Statistical Analysis

Continuous variables were summarized as mean $\pm$ standard deviation where available and categorical variables as number and percentage. Serial NRS values were assessed using repeated-measures analysis, and paired RI values using paired analysis. Reported statistical results should be verified against the original patient-level Excel dataset before submission.

RESULTS

Variable	Value
Patients	25
Age	59.1 $\pm$ 9.3 years
Male	22 (88%)
Fontaine III	14 (56%)
Fontaine IV	11 (44%)
Diabetes	10 (40%)
Gangrene	5 (20%)

Pain Outcomes

Time	Mean NRS	Median
Baseline	9.60	10
Immediate	3.40	3
24 hours	2.80	2
1 week	2.04	2
1 month	1.56	1
3 months	1.12	1

Serial pain reduction was statistically significant in the previously reported analysis ($p < 0.001$).

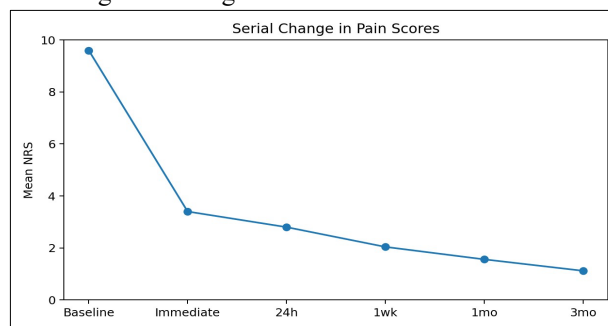


Figure 1. Serial change in mean NRS pain scores.

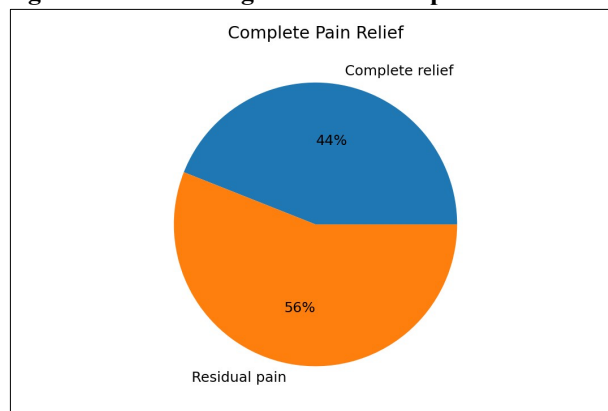


Figure 2. Complete pain relief at last available follow-up

Fontaine Subgroup Analysis

Stage	n	Mean NRS reduction $\pm$ SD
III	14	9.43 $\pm$ 0.65
IV	11	7.27 $\pm$ 0.90

Exploratory subgroup analysis previously reported greater pain reduction in Fontaine III disease ($p < 0.001$).

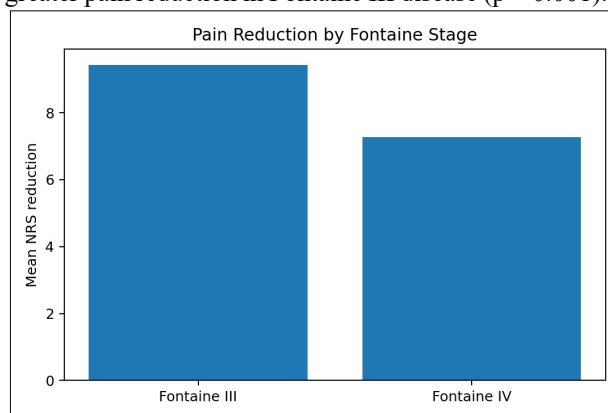


Figure 3. Pain reduction according to Fontaine stage

Doppler Outcomes

Parameter	Mean $\pm$ SD
Pre-procedure RI	0.654 $\pm$ 0.042
Post-procedure RI	0.569 $\pm$ 0.029
Mean reduction	0.084 $\pm$ 0.030

The immediate reduction in RI was statistically significant in the previously reported paired analysis ($p < 0.001$).

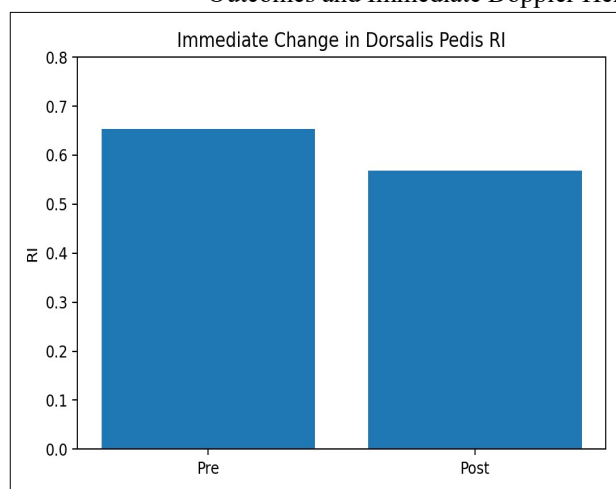


Figure 4. Immediate change in dorsalis pedis artery RI

Safety and Limb Outcomes

Technical success and immediate sympathetic response were documented in all 25 patients. Four patients had recorded complications. Six patients underwent minor toe amputation approximately 2–3 months after neurolysis for gangrenous changes already present before the procedure. No major amputations or deaths were reported.

Discussion

The principal finding of this study was a substantial and sustained reduction in ischemic rest pain following CT-guided lumbar sympathetic neurolysis. Mean NRS decreased from 9.60 at baseline to 3.40 immediately after the procedure and progressively decreased to 1.12 at three months.

The serial assessment of pain is an important strength of the present study because it demonstrates both immediate and sustained clinical response.

Lumbar sympathetic neurolysis may reduce ischemic pain through multiple mechanisms. Interruption of sympathetic vasoconstrictor activity may reduce peripheral vascular resistance and alter regional blood flow. In addition, interruption of sympathetically maintained pain pathways may contribute to the observed analgesic response. The role of lumbar sympathectomy has historically been considered primarily in patients with severe ischemic symptoms when conventional revascularization options are limited.^{1,3}

The findings of the present study are consistent with the CT-guided lumbar sympathectomy outcomes reported by Chahal *et al.*, who demonstrated substantial pain reduction following CT-guided chemical lumbar sympathectomy in patients with CLTI. Importantly, their study demonstrated that medial spread of the neurolytic agent was associated with superior long-term clinical outcomes compared with predominantly lateral spread.⁴ This observation highlights the importance of accurate needle placement and confirmation of satisfactory injectate distribution.

A notable finding in the present study was the significant immediate reduction in dorsalis pedis artery RI following neurolysis. The reduction from 0.654 before the procedure to 0.569 immediately afterward suggests an acute alteration in distal peripheral arterial resistance following sympathetic interruption.

Objective indicators of successful lumbar sympathetic blockade have previously been evaluated using changes in skin temperature. Park *et al.* demonstrated that a rapid increase in ipsilateral lowerextremity temperature could predict successful sympathetic blockade.⁵ Other studies have similarly reported significant changes in distal cutaneous temperature following lumbar sympathetic block.⁶

Although the immediate RI reduction observed in the present study provides an objective Doppler parameter, it should be interpreted cautiously. RI is influenced by downstream vascular resistance and arterial hemodynamics and does not directly measure tissue perfusion, microvascular circulation, or limb oxygenation. Therefore, the observed RI change should be interpreted as evidence of an acute hemodynamic alteration rather than definitive evidence of improved tissue perfusion.

The exploratory subgroup analysis demonstrated greater pain reduction in patients with Fontaine stage III disease compared with those with Fontaine stage IV disease. One possible explanation is that patients with advanced tissue loss may experience pain related not only to ischemia but also to ulceration, tissue necrosis, infection, and gangrene. However, the sample size was limited, and this observation should be interpreted as hypothesis-generating.

Technical success was achieved in all patients. The use of CT guidance likely contributed to the high technical success rate by allowing visualization of the vertebral bodies, psoas muscle, needle trajectory, and injectate distribution.

The present study also provides a detailed and reproducible CT planning technique. Planning was performed using sagittal identification of L2, L3, and L4, followed by axial determination of the intended tangential trajectory. Measurements from the spinous process to the planned trajectory were subsequently transferred to the patient's skin. Patients were instructed not to move until completion of skin marking. This practical step may help reduce discrepancies between CT planning and needle placement.

Six patients underwent minor toe amputation during follow-up. However, all amputations were performed for gangrenous tissue that was present before the neurolysis procedure. Therefore, these amputations should not be interpreted as direct procedural complications. No major amputations were recorded during the available follow-up.

Nevertheless, the present study should not claim that lumbar sympathetic neurolysis prevented major amputation. The absence of a control group and the

CT-Guided Lumbar Sympathetic Neurolysis for Ischemic Rest Pain in Chronic Limb-Threatening Ischemia: Clinical Outcomes and Immediate Doppler Hemodynamic Changes in a Single-Center Cohort

limited duration of follow-up do not permit conclusions regarding limb salvage.

The evidence base for lumbar sympathectomy in CLTI remains limited. A Cochrane review found no eligible contemporary randomized controlled trials comparing lumbar sympathectomy with no treatment or alternative approaches in patients with non-reconstructable critical limb ischemia.³ Therefore, high-quality prospective studies remain necessary.

The present findings suggest that CT-guided lumbar sympathetic neurolysis may have a role as a symptom-directed treatment for selected patients with severe ischemic rest pain, particularly when pain remains a major clinical problem.

Limitations

The study is limited by small sample size, single-center observational design, absence of a control group, limited follow-up, possible effects of concomitant treatments, and the use of immediate RI as a surrogate hemodynamic marker. Subgroup analyses should be interpreted as exploratory.

Conclusion

CT-guided lumbar sympathetic neurolysis was associated with substantial and sustained reduction in ischemic rest pain in this cohort of patients with chronic limb-threatening ischemia.

Pain scores demonstrated significant improvement immediately following the procedure and remained substantially reduced at three months.

The procedure achieved a high technical success rate and was associated with a significant immediate reduction in dorsalis pedis artery resistive index, suggesting an acute alteration in peripheral arterial hemodynamics following sympathetic neurolysis.

CT-guided lumbar sympathetic neurolysis may represent a useful symptom-directed intervention in appropriately selected patients with severe ischemic rest pain. Larger prospective studies incorporating standardized perfusion assessment, objective confirmation of sympathetic interruption, quality-of-life outcomes, and longer-term follow-up are required.

Clinical Relevance and Implications

The present findings are clinically relevant because ischemic rest pain in chronic limb-threatening ischemia may remain severe despite optimal medical therapy and, in selected patients, may persist when revascularization is not feasible, has failed, or does not adequately address symptoms. In such situations, CT-guided lumbar sympathetic neurolysis may serve as a symptom-directed adjunct rather than a replacement for revascularization or comprehensive vascular care.

The marked reduction in pain observed immediately after the procedure and its persistence through the available follow-up suggest that chemical interruption of the lumbar sympathetic pathway may provide clinically meaningful analgesia in appropriately selected patients. The present study does not establish improvement in limb salvage or survival; however, reduction of severe

ischemic rest pain itself may represent an important patient-centred outcome.

Interpretation of the Doppler Findings

An important exploratory component of the present study was the assessment of the dorsalis pedis artery resistive index immediately before and after neurolysis. The significant reduction in RI provides an objective vascular observation accompanying the clinical improvement in pain. Sympathetic interruption can theoretically reduce vasomotor tone and alter distal arterial resistance. Nevertheless, RI is a derived Doppler parameter and can be influenced by waveform morphology, downstream vascular resistance, collateral circulation, arterial stiffness, and technical factors.

Accordingly, the immediate reduction in RI should not be interpreted as proof of improved macrovascular patency, microvascular perfusion, tissue oxygenation, or wound healing. Rather, it should be presented as an exploratory objective marker of acute hemodynamic alteration following lumbar sympathetic neurolysis. Future studies should correlate Doppler findings with skin temperature, toe pressures, transcutaneous oxygen tension, skin perfusion pressure, or validated perfusion imaging methods.

Strengths of the Study

Despite the limitations inherent to an observational cohort, the study has several strengths. First, pain was assessed serially at multiple clinically relevant time points, allowing evaluation of both immediate and sustained analgesic response. Second, the procedure was performed using a standardized CT-guided technique targeting L2, L3, and L4 in all patients. Third, the needle gauge, injection sequence, ropivacaine volume, and laterality-specific absolute alcohol volumes were standardized. Fourth, immediate Doppler assessment of the dorsalis pedis artery provided an objective physiologic parameter in addition to subjective pain assessment. Finally, the study provides a detailed and reproducible description of CT-based trajectory planning and skin marking, which may be of practical value to interventional radiologists performing this procedure.

Future Research

Future prospective studies should include a larger sample size and longer follow-up and should ideally compare lumbar sympathetic neurolysis with optimized medical management or other symptom-directed interventions. Standardized assessment of analgesic consumption, quality of life, functional status, wound healing, limb salvage, and major adverse limb events would provide a more comprehensive understanding of clinical benefit. Objective confirmation of sympathetic interruption should also be incorporated using predefined measures such as bilateral skin temperature change, perfusion index, toe pressures, transcutaneous oxygen tension, or skin perfusion pressure. In addition, the relationship between neurolytic-agent distribution on CT and clinical outcome should be prospectively evaluated.

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