Role of laparoscopic lumbar sympathectomy in chronic limb-threatening ischemia due to nonreconstructable peripheral arterial disease

Ahmed H.S. Ahmed, Amr A. Mahmoud, Wageeh F. Abdelmalek, Mohamed A.E.M. Rizk

Department of Vascular Surgery, Faculty of Medicine, Ain Shams University, Cairo, Egypt

Correspondence to Ahmed H.S. Ahmed, Master's degree in general surgery, Department of Vascular Surgery, Faculty of Medicine, Ain Shams University, Cairo 35111, Egypt. Tel: +20 109 749 7249; e-mail: ahmedheshmat1990@gmail.com

Received: 16 November 2023
Revised: 2 December 2023
Accepted: 9 December 2023
Published: 31 January 2024

The Egyptian Journal of Surgery 2024, 43:296–303

Background
Lumbar sympathectomy (LS) was traditionally performed for intermittent claudication but is now eclipsed by revascularization for that indication. However, it retains a role in the management of chronic limb-threatening ischemia and other conditions causing lower limb pain with or without ischemia. In this study, we identify its role in the management of chronic limb-threatening ischemia in cases of nonreconstructable peripheral arterial disease.

Aim
The main aim of this study is to determine if LS procedure has an effective role in limb salvage and pain control for patients with nonreconstructable peripheral limb ischemia. The primary endpoint was limb salvage in the target limb, while the secondary endpoint targeted assessment of pain improvement in the same limb.

Patients and methods
This study is a prospective single-arm cohort study conducted using 21 patients between the January 1, 2021 and the January 1, 2023 at two hospitals, Ain Shams University Hospital and Nasser Institute Hospital. Patients complained of nonreconstructable peripheral arterial disease and there was no chance for revascularization either endovascular or surgical bypass.

Results
This study included 60 patients; one patient was excluded due to being lost to follow-up, and presented with nonconstructable critical limb ischemia between the January 1, 2021 and the January 1, 2023. There were 42 (70%) males and 18 (30%) females. Follow-up for all patients was subjected to measurement of ankle brachial pressure index, digital pulse oximetry, toe pressure and numerical rating scale for pain scoring preoperative and postoperative. On follow-up we noticed that there was no change in either ankle brachial pressure index or toe pressure immediately postoperatively and after 12 months. However, the digital pulse oximetry showed significant improvement immediately postoperatively from 68.40±7.36 to 81.15 ±12.23 with a *P* value of 0.001. The most remarkable improvement was found in pain scoring immediately, 1, 3, 6, and 12 months postoperatively with *P* values showing statistical significance. As for limb salvage, there was a 100% limb survival for 3 months. After 6 months, only nine cases underwent above-knee amputation, one of them was due to severe limb infection, and three cases had minor amputation 'toe amputation.' We noticed that three out of the nine cases suffering major amputations had femoropopliteal disease. Of the patients, 80% suffered no minor or major amputation, while 15% had major amputations beyond the tarsometatarsal joint and only 5% underwent minor toe amputation or debridement. Fortunately, there was no mortality among the studied cases.

Conclusion
Retroperitoneoscopic LS is significantly less invasive than open surgical technique with fewer wound complications and less hospital stay period and offers a longer duration of pain relief and less incidence of recurrence of manifestations.

Keywords:
chronic limb-threatening ischemia, laparoscopic lumbar sympathectomy, nonreconstructable peripheral arterial disease

Egyptian J Surgery 43:296–303

1110-1121

Introduction

Lumbar sympathectomy (LS) was traditionally performed for intermittent claudication but is now eclipsed by revascularization for that indication.

However, it retains a role in the management of chronic limb-threatening ischemia (CLTI) and other conditions causing lower limb pain with or without ischemia. In this study, we identify its role in the management of CLTI in cases of nonreconstructable peripheral arterial disease (PAD).

Lower limb PAD refers to the obstruction or narrowing of the large arteries of the lower limbs, mostly caused by atheromatous plaque or a thrombus (blood clot). The most common cause of PAD is atherosclerosis, which affects more than 200 million people worldwide [1]. Risk factors for PAD include smoking, diabetes, hypertension, and high cholesterol [2]. People who suffer from PAD have an increased risk of suffering from cardiovascular problems, including myocardial infarction, stroke, and death from cardiovascular disease [3].

CLTI includes clinical patterns with threatened limb viability related to several factors. In contrast to the former term 'critical limb ischemia,' severe ischemia is not the only underlying cause. Three issues must be considered with the former terminology of critical limb ischemia. First, 'critical' implies that treatment is urgent to avoid limb loss, while some patients can keep their legs for extended periods even in the absence of revascularization [4].

The management of patients with CLTI must start with the best medical treatment along with the correction of risk factors. In those with diabetes, glycemic control is particularly important for improved limb-related outcomes, including lower rates of major amputation and increased patency after infrapopliteal revascularization [5]. Proper wound care must be started immediately, as well as the use of adapted footwear, treatment of concomitant infection, and pain control. So far, only one randomized trial, the Bypass versus Angioplasty in Severe Ischemia of the Leg (BASIL) trial, has directly compared endovascular therapy with open surgery in CLTI patients [6]. At 2 years, there was no significant difference between endovascular therapy and surgery regarding amputation-free survival. In survivors after 2 years, bypass surgery was associated with improved survival (on average 7 months, P=0.02) and amputation-free survival (6 months, P=0.06) [7]. These data are challenged by more recent endovascular therapy techniques. So far, drug-eluting balloons in below-the-knee disease have shown no superiority over plain balloon angioplasty [8].

The results of two ongoing randomized controlled trials, Bypass versus Angioplasty in Severe Ischemia of the Leg (BASIL-2) and Best Endovascular vs. Best Surgical Therapy in Patients with Critical Limb Ischemia (BESTCLI), are awaited [9]. Meanwhile, in each anatomical region, both revascularization options should be individually discussed.

Treatment of PAD with amputation of the affected limb has been decreasing, which has coincided with an increase in surgical and endovascular procedures to improve blood flow [10].

However, many people have nonreconstructable diseases with extremely poor distal blood flow and often undergo major amputation for the relief of rest pain. Amputation rates for pain relief in these people are high, up to 45%, because the treatment options are extremely limited. LS and prostanoid infusion are alternative treatment options for people with PAD, who are not suitable for endovascular or surgical repair [11].

LS spans two centuries of surgical practice [12]. Originally developed as a treatment for peripheral vascular disease (PAD), it has since been eclipsed by the advent of more definitive surgical options such as arterial bypass and endovascular treatment [13]. LS results in reflex dilation of vasculature from loss of sympathetic tone, of superficial arterioles, facilitating improved blood flow and skin perfusion [14]. LS can be beneficial for patients with other conditions including hyperhidrosis, diabetic neuropathy, and vasospastic disorders [15]. Patients suffering intractable pain from a variety of etiologies also benefit from LS [16].

Aim

The main aim of this study is to assess the role of LS procedure has an effective role in limb salvage and pain control for patients with nonreconstructable peripheral limb ischemia.

The primary endpoint was limb salvage in the target limb, while the secondary endpoint targeted assessment of pain improvement in the same limb.

Patients and methods

This study is a prospective single-arm cohort study that was conducted using 21 patients between the January 1, 2021 and the January 1, 2023 at Ain Shams University Hospital and Nasser Institute Hospital. Patients who presented with nonreconstructable PAD and with no chance for revascularization, either through endovascular procedures or surgical bypass were observed.

Inclusion criteria

Age from 18 to 75 years, patients who underwent failed surgical or endovascular attempts of revascularization, poor runoff and/or absent pedal and planter arch that prohibit successful revascularization, patients who did not sign the consent, refused to be enrolled in the study or lost to follow-up.

Exclusion criteria

Diabetic neuropathic pain, the patient presented with major tissue loss or severe infection that render limb loss and amputation, disabled or nonmobile patients, and patients who are surgically unfit for the procedures according to the American Society of Anesthesiologists scoring system 'ASA score 3–4.'

Study tools

Observational checklist including blood pressure, blood sugar, lipid profile, and immune assay was observed among all patients. Computed tomography angiography and arterial duplex preoperative and postoperative. Patients were classified according to Rutherford, WIFI, and GLASS scoring systems for prediction of limb survival.

Surgical procedure

The procedure was performed under general anesthesia. The patient was positioned in lateral decubitus, and the surgical table was flexed for the creation of maximal exposure of the area between the costal margin and the iliac crest at the level of the umbilicus. An incision of about 1.5–2.0 cm was made at the anterior axillary line midway between the costal margin and the iliac crest. Further dissection was done through the external and internal oblique muscles by separation of their respective fibers to reach the retroperitoneal space. The areolar fatty tissue was dissected, while the peritoneal sac was gently pushed forward using a blunt finger, which creates a safe space insertion of the distention balloon system into the retroperitoneum. The balloon then is inflated under vision using a 30° camera introduced through a balloon trocar. The fully inflated balloon is left in place for 2–5 min to ensure proper hemostasis, it can be deflated and removed afterward. If any tear was detected in the peritoneum, the procedure could be continued. Often the peritoneum can be repaired with direct vision with S-shaped retractors after the removal of the balloon trocar. Using the balloon distension system made the procedure even less traumatic and enabled us to achieve the exposure without any significant trauma or complication.

After that, a trocar was introduced into the previously created space. The space created is insufflated with CO_2 to a pressure of 10–12 mmHg. Another two 5-mm ports are inserted with direct vision into the retroperitoneal space at the mid and posterior axillary lines, approximately one inch behind the first one (Fig. 1).

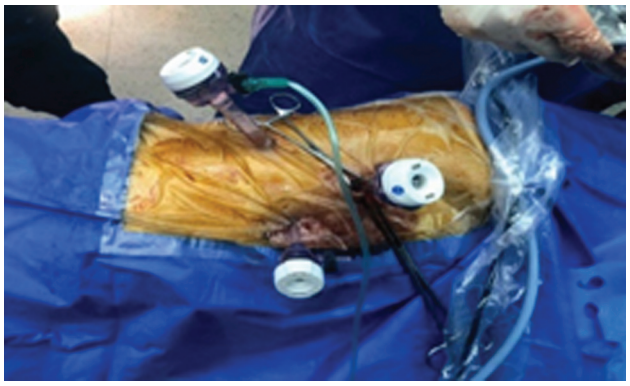
The vertebrae in the paravertebral space were palpated with laparoscopic instruments, and the dissection of this space started at the medial border of the psoas muscle and close to the vertebrae two instruments were used for traction, dissection, clipping, and cutting. The sympathetic chain was identified anterior to the vertebral column along the medial border of the psoas muscle, and small communicating rami and blood vessels were divided with cautery for hemostasis. Care was exercised in dissection near the sympathetic trunk and ganglia to avoid injuring lumbar vessels in the area. The sympathetic chain was then transected between clips at the level of the ganglia, second lumbar vertebrae (L2), and L4 and then removed. The sympathetic ganglion at the level of the third lumbar vertebra is the most obviously visualized in the operative field after the dissection and exposure of the sympathetic ganglia (Fig. 2).

Using the retroperitoneal approach, there seems to be no increased technical difficulty in the performance of the procedure on either the right or the left side. The excised ganglia were sent for histopathologic examination and verification. The retroperitoneal space is deflated, the trocars are removed, and the fascia at the large port site is sutured. Skin incisions and the underlying anterior wall were closed using Prolene sutures.

Statistical analysis

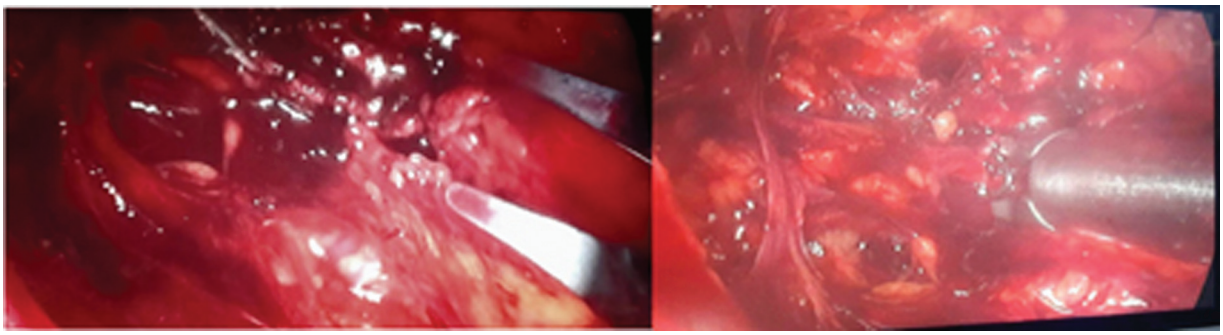
Data analysis was performed using SPSS software, version 25 (SPSS Inc., statistics for Windows

Figure 1



Trocars insertion with the patient head position on the right side of the picture.

Figure 2



Clipping of L2 and L3 sympathetic ganglia.

Table 1 Sociodemographic characteristics of the studied cases

	N=60 [*n* (%)]
Age (years)	
Mean±SD (minimum–maximum)	41.6±10.12 (25–60)
Sex	
Male	42 (70.0)
Female	18 (30.0)
Current	
Smokers	15 (25.0)
Ex-smokers	45 (75.0)

version 25; SPSS Inc., Chicago, Illinois, USA). Qualitative data were described using numbers and percentages. Quantitative data were described using median (minimum and maximum) for nonnormally distributed data and mean±SD for normally distributed data after testing normality using the Kolmogorov–Smirnov test. The significance of the obtained results was judged at the *P* value less than or equal to 0.05 level. Wilcoxon signed-rank test was used to compare between more than two studied periods. The paired *t* test was used to compare two paired readings for normally distributed data.

Ethical approval statement

Consent Ethical approval to report these cases was given by Ethical committee of Ain Shams University hospitals. Written informed consent was obtained from the patients.

Results

This study included 21 patients, one patient was excluded due to being lost to follow-up, and presented with nonconstructable critical limb ischemia between the January 1, 2021 and the January 1, 2023. There were 14 (70%) males and six (30%) females. The age range of patients was 25–60 years, with a mean age of 41.6±10.12. There were five (25%) active smoker patients and 14 (75%) ex-smokers. There were nine(45%) hypertensive patients, nine (45%) hypercholesteremic patients, and three (15%) with mild controlled ischemic heart disease. There were no diabetic patients, no congestive heart failure, or cerebrovascular accidents reported. American Society of Anesthesiologists grade classification for all the patients was 2. Demographic data and risk factors are listed in Tables 1 and 2.

Multiple different scoring systems were used to classify our patients according to the grade of ischemia, wound criteria, and anatomical considerations. Many patients complained of ischemic rest pain in the lower limbs comprising 65%, while the remaining 35% suffered minor tissue loss or gangrene with diffuse pedal ischemia, which means that according to Rutherford classification patients ranged between category 4 and category 5, respectively. Adding to that, only 30% of patients suffered from mild local infection. Also, all cases had an ankle brachial pressure index (ABPI) of less than 0.39 denoting severe ischemia. When all the previous data was applied to the WIFI scoring system, â 60% of patients were in stage 2.

According to the GLASS anatomical scoring system, 70% of patients had no significant disease in the femoropopliteal segment. However, all studied cases

Table 2 Medical history among studied cases

	N=60 [*n* (%)]
Obesity	6 (10.0)
DM	0
Hypertension	27 (45.0)
Hypercholesterolemia	27 (45.0)
IHD	9 (15.0)
CHF	0
CVA	0
ASA grade 2	60 (100.0)

ASA, American Society of Anesthesiologists; DM, diabetes mellitus; IHD, ischemic heart disease.

Table 3 GLASS score for anatomical consideration of studied cases

Anatomical consideration	*N*=60 [*n* (%)]
Femoropopliteal	
No significant disease	42 (70.0)
Total SFA>20	18 (30.0)
Tibial two	60 (100.0)
Pedal two	60 (100.0)

showed severe disease or total occlusion in the tibial and pedal segments, indicating that all our cases had no proper runoff for revascularization either through balloon angioplasty or surgical bypass, as shown in Table 3.

Half of the patients underwent sympathectomy on the left side and the other half on the right side, none of the cases underwent bilateral LS. Sympathetic ganglia at the level of lumbar L2 and L3 vertebrae were excised under general anesthesia in all cases and confirmed by histopathological examination. Only one patient had a previous successful trial of chemical sympathectomy 1 year before our intervention with a recurrence of rest pain after 6 months of the previous procedure. Also, half of our patients were subjected to multiple failed trials of revascularization as shown in Table 4.

Follow-up for all patients was subjected to measurement of ABPI, digital pulse oximetry, toe pressure, and numerical rating scale for pain scoring preoperatively and postoperatively. On follow-up, we noticed that there was no change in either ABPI or toe pressure immediately postoperatively and after 12 months. The digital pulse oximetry showed significant improvement immediately postoperatively from 68.40±7.36 to 81.15±12.23 with a *P* value of 0.001; however further follow-up could not be feasible at the time of study with that test. The most remarkable

Table 4 Sympathectomy criteria distribution among studied cases

Sympathectomy	*N*=60 [*n* (%)]
Side of sympathectomy	
Right	30 (50.0)
Left	30 (50.0)
Type anesthesia	
General anesthesia	60 (100.0)
Level of removed ganglion. (L2, L3)	60 (100.0)
History of previous sympathectomy	3 (5.0)
History of previous revascularization	30 (50.0)

improvement was found in pain scoring immediately, 1, 3, 6, and 12 months postoperatively with *P* values showing statistical significance as shown in Table 5.

As for limb salvage, there was a 100% limb survival for 3 months. After 6 months, only nine cases underwent above-knee amputation, one of them was due to severe limb infection, and three cases had minor amputation 'toe amputation.' We noticed that three out of the nine cases suffering major amputations had femoropopliteal disease; 80% of the patients suffered no minor or major amputation, while 15% had major amputations beyond the tarsometatarsal joint and only 5% underwent minor toe amputation or debridement. Fortunately, there was no mortality among studied cases (Figs 3 and 4).

Discussion

LS retains a role in the management of CLTI and other conditions causing lower limb pain with or without ischemia. In this study, we identify its role in the management of CLTI in cases of nonreconstructable PAD.

We enrolled 60 patients in our study out of which only 20 patients were included, one patient was excluded for

Table 5 Comparison of ABI, digital pulse oximetry, toe pressure, and pain scale score during follow-up for the studied cases

	Preoperative (*N*=60) [*n* (%)]	Immediate (*N*=60) [*n* (%)]	1 months postoperative (*N*=60) [*n* (%)]	3 months postoperative (*N*=60) [*n* (%)]	6 months postoperative (*N*=60) [*n* (%)]	12 months postoperative (*N*=60) [*n* (%)]	Test of significance[#]
ABI <0.3	60 (100)	60 (100)	60 (100)	60 (100)	60 (100)	60 (100)	*P*1=1.0 *P*2=1.0 *P*3=1.0 *P*4=1.0
Digital pulse oximetry	68.40±7.36	81.15 ±12.23	ND	ND	ND	ND	*P*1=0.001*
Toe pressure	0	0	0	0	0	0	
Pain scale score median (minimum–maximum)	8 (7–9)	2.0 (0–10)	2 (0–10)	2 (0–10)	1 (0–9)	1 (0–9)	*P*1<0.001* *P*2=0.003* *P*3=0.001* *P*4<0.001* *P*5<0.001*

*P*1: comparison between preoperative and immediate follow-up. *P*2: the difference between preoperative and 1-month postoperative. *P*3: preoperative and 3 months postoperative. *P*4: the difference between preoperative and 6 months postoperative. *P*5: comparison between preoperative and at 12 month follow-up. *Statistically significant. [#]Paired *t* test and Wilcoxon signed-rank test.

Figure 3

(a) Preoperative, nonhealing infected wound on the dorsum of the fifth metatarsal and (b) complete healing of the wound 1 month postoperatively.

Figure 4

(a) On the left side: preoperative image showing dry gangrene of the little toe and (b) on the right side: 2 weeks with complete healing of amputation wound.

lack of compliance during follow-up with a male to female ratio of 2.3, and three out of four patients were current smokers. All our patients complained of nonreconstructable PAD presented by either rest pain, minor tissue loss, or gangrene. All patients in our study were subjected to unilateral retroperitoneoscopic sympathectomy with 100% technical success confirmed by histopathological examination, with no major intraoperative or postoperative complications through the period of study.

On stratifying our patients, 65% of patients were complaining of rest pain only, while the other 35% had added minor wounds, tissue loss, or gangrene with mild local infection (WIFI score 2–3). In terms of the extent of vascular disease, all patients suffered infrapopliteal severe disease, while only 18 patients had added a total superficial femoral artery occlusion more than 20 cm in length.

On follow-up, 42 out of 60 patients experienced marked improvement of their pain and quality of life immediately postoperatively with improvement of oxygen saturation measured by a pulse oximeter and only three patients suffered recurrence of pain after 6 months. In terms of wound healing, nine out of 18 patients experienced wound healing in different periods of time.

According to limb salvageability, there was a 100% limb survival for 3 months. Only nine cases of above-knee amputation, three of them were due to severe limb infection, after 6 months and three cases had a minor amputation. We noticed that one out of the nine cases suffering major amputation had femoropopliteal disease. After 12 months of follow-up, there was a total of nine major amputations out of 60 patients.

Maguire and colleagues, in their retrospective single-center study, underwent 27 open surgical approach procedures on 24 patients during this period; 75% of patients were male and 25% were female. Maguire and colleagues performed 21 unilateral and three bilateral cases through an open surgical approach. One patient

developed intraoperative bleeding from a lumbar vein, which was successfully ligated. Blood transfusion was not required, and the length of hospital stay was not affected. Only 16 patients out of 24 were diagnosed with PAD without further details about the presentation of ischemia in those patients. Despite the longer duration of follow-up, 1 year, and a good percentage of improved outcomes in terms of improved symptomatology, there is a long gap between follow-up appointments.

Maguire and colleagues reported improvement of symptoms in almost two out of three patients who underwent LS for PAD indications at the 1-year follow-up. Maguire *et al*. [17] reported only 14.8% of his patients proceeded to major amputation with a mean time to amputation of 3 months.

Kothari and colleagues had a total of 167 percutaneous chemical lumbar sympathectomy (PCLS) procedures performed on 147 patients diagnosed with Buerger's disease in the surgery department of a teaching hospital in Central India from June 2008 to January 2016. All patients were chronic bidi smokers, males; most patients were in their third decade of life. On reviewing the Kothari and colleagues study, the availability of imaging modality affected his choice. The imaging modality for the first 67 PCLS (five bilateral) was a computed tomography scan. In another group, digital radiography (total 50, seven bilateral) and Câ arm image intensifier (total 50, eight bilateral) were used for the next 100 patients. The three groups had the same results. All patients had PAD in the form of ischemic rest pain or minor tissue loss such as toe gangrene or foot ulcer. ABPI could not be assessed in most patients.

Kothari reported a success rate of 82–86.7% across all the three groups. Excellent rest pain relief was obtained, which lasted for 3 months of followâ up in more than 80% of patients.

Unfortunately, they did not report any follow-up results beyond the period of 3 months. Wound healing was in most patients across the three groups without further specification. A considerable number of limbs (103/167) had gangrene of the toe/multiple toes/part of the forefoot. Of 103 limbs, popliteal pulse was present in 57 (55.33%) limbs. All these limbs healed after amputation of toes/forefoot and PCLS. The other 46 limbs had absent popliteal pulses, only oneâ third of these limbs healed after amputation (of toes/forefoot) and PCLS. The other twoâ thirds had to be subjected to belowâ knee amputations [18].

Beglaibter and colleagues performed 29 successful retroperitoneoscopic LS approach procedures without reporting any complications in all the 27 patients submitted for their trial. Unilateral procedures were done for 25 patients, while the remaining patients underwent bilateral procedures in two stages. Computed tomography scan-guided chemical sympathectomy was previously done on five of their patients. On immediate postoperative follow-up, the affected limb was found to be warm and dry on assessment.

On follow-up, they reported a long-term improvement of pain in the affected limb in both vascular and reflex sympathetic dystrophy complaints. However, there was no significant improvement in trophic changes in the patients with reflex sympathetic dystrophy. A single patient complaining of a nonhealing leg ulcer that was associated with vasculitis underwent successful wound coverage with a skin graft after the sympathectomy.

However, in terms of limb survival, they reported three minor amputations for gangrene. One of the patients who underwent amputation had Buerger's disease, and the other two had peripheral vascular disease [19].

Karanth and colleagues, in their intervention review of literature, identified no randomized controlled trials assessing the effects of LS by open, laparoscopic, and percutaneous methods compared with no treatment or compared with any other method of LS in patients with critical lower limb ischemia due to nonreconstructable PAD [20].

To summarize, these patients were selected for LS as they had exhausted all revascularization and pain management options. All the previous discussion suggests that LS can not only save limbs from major amputation but can also allow.

Conclusion

LS is an attractive solution for patients who are deemed not responsive to ordinary revascularization techniques. It helps not only in pain management but also as a strong factor in preventing limb loss and improving patients' quality of life. Retroperitoneoscopic LS is proved to be quite preferable over PCLS or open surgical sympathectomy. It is significantly less invasive than the open surgical technique with fewer wound complications and less hospital stay period and offers a longer duration of pain relief and less incidence of recurrence of manifestations.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1 Kullo IJ, Rooke TW. Peripheral artery disease. N Engl J Med 2016; 374:861–871.

2 Fowkes RG, Rudan D, Rudan I, Aboyans V, Denenberg JO, McDermott MM. Comparison of global estimates of prevalence and risk factors for peripheral artery disease in 2000 and 2010: a systematic review and analysis. Lancet 2013; 382:1329–1340.

3 Steg G, Bhatt DL, Wilson WF. One-year cardiovascular event rates in outpatients with atherothrombosis. JAMA 2007; 297:1197–1206.

4 Brass EP, Anthony R, Dormandy J, Hiatt WR, Jiao J, Nakanishi A, *et al.* Parenteral therapy with lipo-ecraprost, a lipid-based formulation of a PGE1 analog, does not alter six-month outcomes in patients with critical leg ischemia. J Vasc Surg 2006; 43:752–759.

5 Singh S, Armstrong EJ, Sherif W, Alvandi B, Westin GG, Singh GD, *et al.* Association of elevated fasting glucose with lower patency and increased major adverse limb events among patients with diabetes undergoing infrapopliteal balloon angioplasty. Vasc Med 2014; 19:307–314.

6 Adam DJ, Beard JD, Cleveland T, Bell J, Bradbury AW, Forbes JF, *et al.* Bypass versus angioplasty in severe ischemia of the leg (BASIL): multicenter, randomized controlled trial. Lancet 2005; 366:1925–1934.

7 Bradbury AW, Adam DJ, Bell J, Forbes JF, Fowkes FG, Gillespie I, *et al.* Bypass versus Angioplasty in Severe Ischemia of the Leg (BASIL) trial: a survival prediction model to facilitate clinical decision making. J Vasc Surg 2010; 51:52s–68s.

8 Zeller T, Baumgartner I, Scheinert D, Brodmann M, Bosiers M, Micari A, *et al.* Drug-eluting balloon versus standard balloon angioplasty for infrapopliteal arterial revascularization in critical limb ischemia: 12-month results from the IN. PACT DEEP randomized trial. J Am Coll Cardiol 2014; 64:1568–1576.

9 Popplewell MA, Davies H, Jarrett H, Bate G, Grant M, Patel S, *et al.* Bypass versus angio plasty in severe ischaemia of the leg – 2 (BASIL-2) trial: study protocol for a randomised controlled trial. Trials 2016; 17:11.

10 Rowe V, Lee W, Weaver FA, Etzioni D. Patterns of treatment for peripheral arterial disease in the United States:1996–2005. J Vasc Surg 2009; 49:910.

11 Lee AD, Agarwal S, Sadhu D. A 7-year experience with thoracoscopic sympathectomy for critical upper limb ischemia. World J Surg 2006; 30:1644.

12 Langeron P, Bastide G. Lumbar sympathectomy for arteritis. A reliable and (almost) seventy-year-old technique. Chirurgie 1992; 118:522–528.

13 Ferket BS, Spronk S, Colkesen EB, Hunink MG. Systematic review of guidelines on peripheral artery disease screening. Am J Med 2012; 125:198–208.

14 Charkoudian N. Skin blood flow in adult human thermoregulation: how it works, when it does not, and why. Mayo Clin Proc 2003; 78:603–612.

15 Eisenach JH, Atkinson JL, Fealey RD. Hyperhidrosis: evolving therapies for a well-established phenomenon. Mayo Clin Proc 2005; 80:657–666.

16 Ruiz-Aragon J, Marquez Calderon S. Effectiveness of lumbar sympathectomy in the treatment of occlusive peripheral vascular disease in lower limbs: systematic review. Med Clin (Barc) 2010; 134:477–482.

17 Maguire SC, Fleming CA, O'Brien G, McGreal G. Lumbar sympathectomy can improve symptoms associated with ischaemia, vasculitis, diabetic neuropathy and hyperhidrosis affecting the lower extremities—a single-centre experience. Ir J Med Sci 2018; 187:1045–1049.

18 Kothari R, Maharaj A, Tomar TS, Agarwal P, Sharma D. Percutaneous chemical lumbar sympathectomy for buerger's disease: results in 147 patients. Indian J Vasc Endovasc Surg 2017; 4:185–190.

19 Beglaibter N, Berlatzky Y, Zamir O, Spira RM, Freund HR. Retroperitoneoscopic lumbar sympathectomy. J Vasc Surg 2002; 35:815–817.

20 Karanth VK, Karanth TK, Karanth L. Lumbar sympathectomy techniques for critical lower limb ischaemia due to nonreconstructable peripheral arterial disease. Cochrane Database Syst Rev 2016; 2016:CD011519.