Original Article
Interventional surgery shows efficacy for diabetic patients withperipheral vascular disease

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Abstract: Objective: To analyze the effect of interventional surgery on treatment efficacy and inflammatory cytokine (ICK) levels in diabetic patients with peripheral vascular disease (PVD). Methods: A total of 116 diabetic patients with PVD admitted to the Second Affiliated Hospital of Guangzhou Medical University from August 2020 to March 2022 were selected for this retrospective analysis. Patients were divided into two groups: 58 patients receiving conventional medication were assigned to the control group, while 58 patients receiving interventional surgery in addition to conventional medication were assigned to the research group. Comparative analyses were conducted based on clinical efficacy, symptom relief (limb pain, numbness, intermittent claudication, and coldness), ankle-brachial index (ABI) scores, vascular endothelial growth factor (VEGF), transforming growth factor-β (TGF-β), arterial inner diameter, and ICK levels. Results: The research group demonstrated a significantly higher overall effective rate compared to the control group, with markedly higher ABI scores, faster symptom resolution, increased VEGF and TGF-β levels, greater arterial diameters, and lower ICK levels. Conclusion: Interventional surgery provides superior outcomes compared to conventional medication for treating diabetic patients with PVD, offering greater benefits in terms of ABI improvement, symptom relief, vascular factors, arterial diameter expansion, and ICK reduction.

Keywords: Interventional surgery, diabetics with peripheral vascular diseases, clinical effectiveness, inflammatory cytokines

Introduction

Diabetes mellitus (DM), a prevalent chronic metabolic disease with a high incidence [1], is characterized by persistently elevated blood glucose levels, which may result from various factors such as genetics and dietary habits [2]. As the disease progresses, DM often leads to complications, among which peripheral vascular disease (PVD) is common [3]. In PVD, the vascular walls lose elasticity and thicken, causing arterial hardening and thrombosis, which may lead to vascular occlusion, peripheral sensory dysfunction, and severe outcomes [4]. The disability rate in diabetics with PVD is high, significantly affecting their quality of life [5].

Common symptoms include pain and numbness in the lower extremities, with some patients developing intermittent claudication or deep tissue damage, such as ulcers [6]. Thus, exploring effective treatment strategies for DM is crucial.

Currently, neurotrophic drugs and local dressing changes are commonly used to treat PVD in diabetics, though their efficacy is limited [7]. Recently, interventional surgery has gained attention as a promising treatment option. It offers advantages such as minimal trauma, rapid recovery, and repeatability [8]. Through interventional procedures, doctors can accurately target stenosed or occluded arteries

under imaging guidance and effectively treat the affected areas [9]. This method improves blood supply to the feet, reducing the risk of amputation and enhancing patient prognosis [10]. Given that many diabetic patients suffer from significant lower extremity arteriosclerosis obliterans, interventional surgery can be vital for limb preservation [11], since it reopens affected vessels, restoring blood supply and alleviating ischemic symptoms [12]. Due to the widespread and staged nature of vascular lesions in diabetic feet, traditional surgery often struggles to address the extent of these issues. In contrast, interventional therapy is more flexible [13]. In cases of segmental stenosis, balloon catheters may be used to dilate the vessels, while stents can be implanted for severe stenosis to maintain patency [14]. Furthermore, the combination of glycemic control, anti-infection measures, anticoagulation, microcirculation improvement, and local dressing changes, both before and after interventional treatment, significantly promotes healing of diabetic foot ulcers and reduces disability rates [15]. Interventional therapy has been shown to alleviate ischemic symptoms, reduce pain, and improve prognosis by restoring or increasing blood flow to proximal vessels [16].

In this study, we included 116 diabetic patients with PVD to assess the clinical efficacy of surgical interventional therapy.

Materials and methods

Case selection

This retrospective study was approved by the Ethics Committee of the Second Affiliated Hospital of Guangzhou Medical University. A total of 116 diabetic patients with PVD, admitted from August 2020 to March 2022, were selected. Based on the treatment methods, 58 patients who received conventional medication were assigned to the control group, while 58 patients who received interventional surgery in addition to conventional medication were included in the research group. The specific inclusion and exclusion criteria were as follows:

Inclusion criteria: history of claudication or lower extremity pain at rest; absence of posterior tibial artery pulse or reduced extremity temperature in the lower limbs; arteriosclero-

sis, stenosis, and intimal-medial thickening confirmed by ultrasound of the lower extremities, or an ankle-brachial index (ABI) less than 0.9 or greater than 1.3; complete case data; initial treatment.

Exclusion criteria: history of cerebrovascular accident or acute myocardial infarction within the past 6 months; presence of malignant tumor, abnormal coagulation function, or other vascular disease; severe organ dysfunction; pregnant or lactating women; psychiatric disorder.

Intervention methods

The control group received conventional treatment, which included neurotrophic drugs, local dressing changes, and long-term subcutaneous insulin therapy. Additionally, a scientific diet and exercise plan was implemented.

In the research group, patients underwent interventional surgery in addition to the aforementioned treatments. Preoperative screenings and imaging examinations were conducted to ensure the accuracy and safety of the surgery. ABI was assessed, followed by CT imaging of the lower limb arteries to evaluate the degree and location of arterial stenosis. Under local anesthesia, an anterograde or retrograde femoral artery puncture was performed using the Seldinger technique, and a 5F-6F catheter sheath was inserted for heparinization. Digital subtraction angiography was then used to identify the lesion site. Using a guide wire assistance, appropriately sized balloons were delivered to gradually dilate the narrowed arteries. For more severe lesions, percutaneous transluminal angioplasty and, if necessary, stenting were performed to reinforce the vessels. Postoperatively, patients received subcutaneous injections of low molecular weight heparin at 4100 U every 12 hours for one week. Additionally, clopidogrel was administered at 75 mg/day for 6 months, along with long-term aspirin use (100 mg/day). **Figure 1** shows the recovery of the ulcer area before and after surgery.

Data collection

The following factors were compared between the two groups: clinical effectiveness, symptom resolution (limb pain, numbness, intermittent

Figure 1. Recovery of the ulcer site before and after the operation. A-C: Recovery of right arteriosclerosis occlusion and foot ulcer. D-F: Recovery of sole ulcer. G-I: Recovery of left calf ulcer and diabetic foot.

claudication, and coldness), vascular endothelial growth factor (VEGF), transforming growth factor-β (TGF-β), arterial inner diameters, adverse reactions, and inflammatory cytokines (ICKs) such as tumor necrosis factor (TNF)-α and interleukin (IL)-6. Primary outcome measures included clinical effectiveness, VEGF, TGF-β, adverse reactions, TNF-α, and IL-6, while secondary outcome measures were symptom resolution and arterial inner diameters.

Clinical Effectiveness: Treatment effectiveness was evaluated using the following criteria. "Markedly effective" was defined as a near-complete resolution of symptoms (e.g., coldness, resting pain, intermittent claudication) and a significant increase or normalization in skin temperature. "Effective" indicated symptom improvement and increased skin temperature compared to before treatment. "Ineffective" was defined as failure to meet these criteria. The total effective rate was calculated as the sum of "markedly effective" and "effective" cases, expressed as a percentage of total cases.

Symptom Resolution Time: The time required for resolution of limb pain, numbness, intermittent claudication, and coldness was recorded and compared between the two groups.

ABI Score: A Doppler ultrasound blood flow detector (RD2, Shanghai Jumu Medical Equipment Co., Ltd., ccc0002) was used to measure the ABI. After positioning the patient in a supine position, upper arm blood pressure was measured, followed by the systolic pressure of the dorsalis pedis and bilateral posterior radial arteries to calculate the ABI. ABI is the ratio of ankle to brachial arterial pressure, with values of ABI<0.9 considered abnormal and 0.9≤ABI≤1.3 considered normal.

Vascular Factors: Before and after treatment, 5 ml of venous blood was collected from the patient's elbow in a fasting state to measure VEGF and TGF-β levels. Enzyme-linked immunosorbent assays were used to quantify these growth factors following the corresponding kit instructions (Hangzhou MultiSciences Biotech Co., Ltd., 70-EK183-96, EK981).

Arterial Inner Diameters: The inner diameters of the femoral, popliteal, and dorsalis pedis arteries were measured before and after treatment in both groups.

ICKs: Fasting blood samples were collected from both groups before and after the intervention. After allowing the samples to rest at room temperature for 2 hours, they were centrifuged at 3000 r/min for 20 minutes. Plasma was then extracted, sealed in EP tubes, and stored at -30°C. TNF-α and IL-6 levels were determined using chemiluminescent immunoassays (Shanghai Yuduo Biotech Co., Ltd., H356MR) following the instructions of the corresponding kits (Shanghai ExCell Biology Co., Ltd., EH009, EH004).

Statistical methods

Continuous variables were expressed as mean ± SEM and compared between groups using independent t-tests. Categorical variables, expressed as percentages, were compared using the χ^2 test. Data were analyzed using SPSS

Table 1. Comparative analysis of general data

Indicator	Research group (n=58)	Control group (n=58)	χ^2/t	P
Age (years)	57.34±5.21	59.04±5.37	1.730	0.086
Course of diabetes mellitus (year)	6.21±1.77	6.38±1.46	0.564	0.574
Body mass index (kg/m^2)	24.65±3.21	24.57±3.18	0.135	0.893
Gender			1.694	0.193
Male	24 (41.38)	31 (53.45)		
Female	34 (58.62)	27 (46.55)		
Type of vascular diseases			1.561	0.668
Cardiovascular disease	12 (20.69)	14 (24.14)		
Cerebrovascular disease	10 (17.24)	8 (13.79)		
Retinopathy	25 (43.10)	29 (50.00)		
Others	11 (18.97)	7 (12.07)		
Comorbidities			1.429	0.490
Hypertension	18 (31.03)	16 (27.59)		
Coronary heart disease	24 (41.38)	20 (34.48)		
Hyperlipidaemia	16 (27.59)	22 (37.93)		

Table 2. Comparative analysis of clinical effectiveness

Indicator	Research group (n=58)	Control group (n=58)	χ^2	P
Marked effectiveness	42 (72.41)	15 (25.86)		
Effectiveness	13 (22.41)	26 (44.83)		
Ineffectiveness	3 (5.17)	17 (29.31)		
Total	55 (94.83)	41 (70.69)	11.842	0.001

22.0, with P<0.05 considered statistically significant.

Results

Comparative analysis of general data

There were no significant differences between the research and control groups in terms of age, DM duration, body mass index (BMI), sex, vascular disease type, or comorbidities (all P>0.05) (**Table 1**).

Comparative analysis of clinical effectiveness

The total effective rate was 94.83% in the research group and 70.69% in the control group, indicating significantly higher clinical effectiveness in the research group (P<0.05) (**Table 2**).

Comparative analysis of symptom resolution

The resolution times for symptoms such as limb pain, numbness, intermittent claudication, and coldness were shorter in the research group compared to the control group (P<0.05) (**Table 3**).

Comparative analysis of ABI scores before and after intervention

No significant difference in ABI scores was observed between the groups before intervention ((0.68±0.13) vs. (0.70±0.15), P>0.05). After treatment, both groups showed significant increases in ABI scores, with a greater improvement in the research group ((0.98±0.27) vs. (0.83±0.21), P<0.05) (**Figure 2**).

Comparative analysis of VEGF and TGF-β before and after intervention

Before the intervention, there were no significant differences in VEGF ((112.75±15.34) ng/L vs. (111.38±15.27) ng/L) and TGF-β ((41.45±4.97) ng/mL vs. (41.58±4.89) ng/mL) levels between the two groups (both P>0.05). After intervention, both VEGF ((143.75±20.32) ng/L vs. (122.46±19.74) ng/L) and TGF-β ((56.78±5.09) ng/mL vs. (45.65±5.03) ng/mL)

Table 3. Comparative analysis of symptom resolution time

Group	n	Resolution time of limb pain (months)	Resolution time of limb numbness (months)	Resolution time of intermittent claudication (months)	Resolution time of limb coldness (months)
Research group	58	3.21±0.42	3.13±0.38	3.15±0.41	3.52±0.45
Control group	58	4.45±0.98	4.36±0.89	4.10±0.82	4.61±0.97
t	-	8.857	9.680	7.892	7.763
P	-	<0.001	<0.001	0.001	<0.001
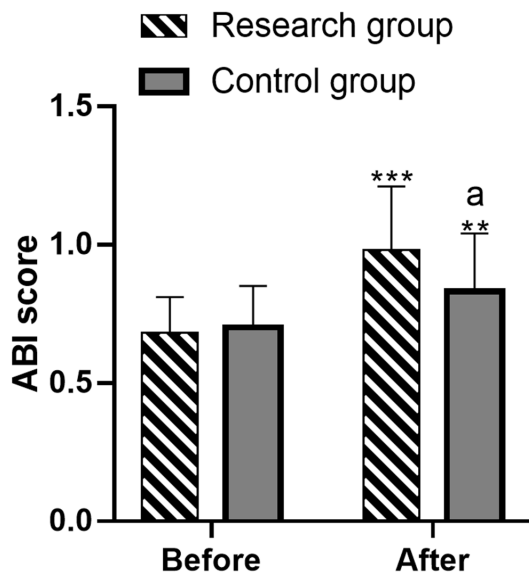
Figure 2. Evaluation of the ankle-brachial index (ABI) scores before and after intervention in two groups. Note: ** denotes P<0.01 versus before treatment, *** denotes P<0.001 versus before treatment, and (a) represents P<0.05 versus the control group.

levels increased in both groups, with significantly higher levels in the research group (both P<0.05) (**Figure 3**).

Comparative analysis of arterial inner diameters

Before intervention, the inner diameters of the femoral ((6.94±0.63) mm vs. (7.02±0.68) mm), popliteal ((5.11±0.24) mm vs. (5.08±0.21) mm), and dorsalis pedis arteries ((1.20±0.14) mm vs. (1.19±0.17) mm) were not significantly different between the groups (all P>0.05). After intervention, the inner diameters of the femoral ((7.75±0.72) mm vs. (7.32±0.64) mm), popliteal ((5.73±0.31) mm vs. (5.31±0.28) mm), and dorsalis pedis arteries ((1.68±0.22) mm vs. (1.27±0.19) mm) increased significantly, with greater enlargement in the research group (all P<0.05) (**Figure 4**).

Comparative analysis of ICKs

Before the intervention, there were no significant differences in TNF-α ((12.33±1.56) pg/mL vs. (13.08±1.71) pg/mL) and IL-6 ((7.34±0.62) pg/mL vs. (8.11±0.64) pg/mL) levels between the two groups (both P>0.05). After intervention, both TNF-α ((3.54±0.21) pg/mL vs. (5.57±0.42) pg/mL) and IL-6 ((2.07±0.21) pg/mL vs. (5.24±0.32) pg/mL) levels decreased significantly, with lower levels in the research group (both P<0.05) (**Figure 5**).

Discussion

Peripheral vascular disease (PVD) is a common and severe complication of DM, particularly affecting the arteries of the lower limbs [17]. Systemic atherosclerosis is a key manifestation of PVD in diabetic patients. When systemic atherosclerosis occurs, thrombosis, plaque formation, and other lesions may develop within the arteries, leading to lumen stenosis and, in severe cases, occlusion, resulting in ischemia in the distal extremities [18, 19]. Atherosclerosis-induced vascular disease severely compromises blood flow in the lower limb arteries. When vascular stenosis or occlusion occurs, blood supply to the feet and surrounding tissues is restricted, causing ischemic symptoms [20]. These symptoms may include pain, weakness, numbness in the lower limbs, and in more severe cases, ulcers or gangrene [21]. In this study, we proposed interventional surgery as an intervention method to evaluate its benefits for diabetic patients with PVD and to provide additional clinical evidence.

The primary advantage of intravascular interventional surgery is its minimally invasive nature. Unlike traditional open surgery, it requires only a small catheter or puncture site to access the blood vessels and directly reach the lesion [22]. This minimally invasive approach reduces intraoperative bleeding and infection
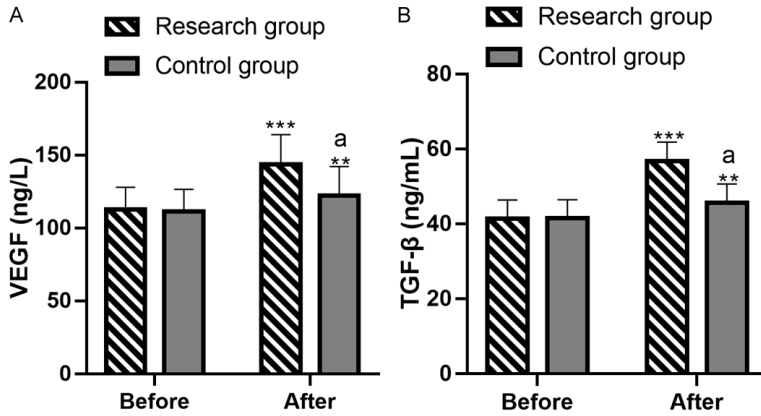
Figure 3. Evaluation of VEGF and TGF-β levels before and after intervention. A: VEGF levels before and after intervention. B: The levels of TGF-β before and after intervention. Note: **P<0.01 *vs.* before treatment, *** denotes P<0.001 versus before treatment; [a]P<0.05 *vs.* Control. VEGF, vascular endothelial growth factor; TGF-β, transforming growth factor-β.
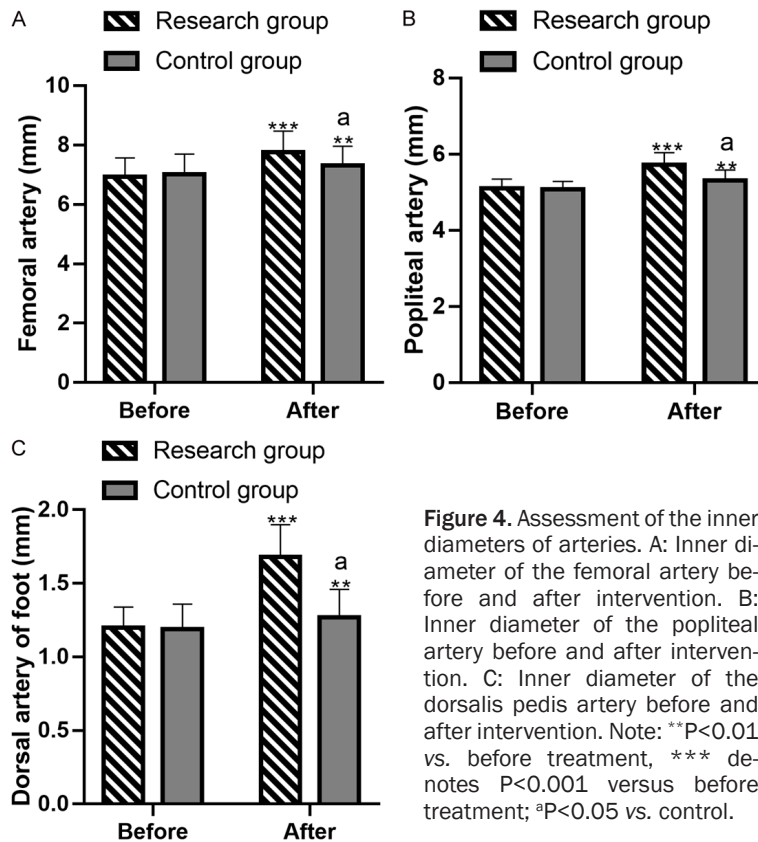
Figure 4. Assessment of the inner diameters of arteries. A: Inner diameter of the femoral artery before and after intervention. B: Inner diameter of the popliteal artery before and after intervention. C: Inner diameter of the dorsalis pedis artery before and after intervention. Note: **P<0.01 *vs.* before treatment, *** denotes P<0.001 versus before treatment; [a]P<0.05 *vs.* control.

tional surgery is effective for DM and peripheral arterial diseases, causing less trauma and promoting faster recovery [25]. In our study, the research group had a total effective rate of 94.83%, significantly higher than the control group (70.69%), suggesting that interventional surgery offers substantial advantages in improving clinical efficacy. Many DM patients experience lower limb pain and, in severe cases, face the risk of amputation due to vascular occlusion [26]. The resolution times for limb pain, numbness, intermittent claudication, and coldness were significantly faster in the research group compared to the control group, indicating that interventional surgery effectively identifies narrowed or occluded arteries, improves blood supply to the affected areas, alleviates disease-related symptoms, and reduces the risk of amputation.

ABI is an important medical marker with high diagnostic value in various diseases [27]. Historically, ABI has been primarily used to detect peripheral arterial disease (PAD) in the lower limbs. By measuring the blood pressure ratio between the ankle and brachial arteries, physicians can assess blood flow insufficiency in the lower extremities, enabling timely detection and treatment of vascular diseases [28]. As medical research has advanced, the application of ABI has

risk, while also allowing for quicker postoperative recovery [23]. The precision of this technique enables targeted treatment of the lesion, enhancing the therapeutic effect [24]. Patients can often return to normal activities sooner. Studies have shown that intravascular interven-

broadened, and it is now an essential criterion for diagnosing PVD in diabetic patients [29]. In diabetic patients, ABI measurement helps assess PVD risk, allowing clinicians to develop personalized treatment plans, thereby improving treatment outcome and quality of life [30].
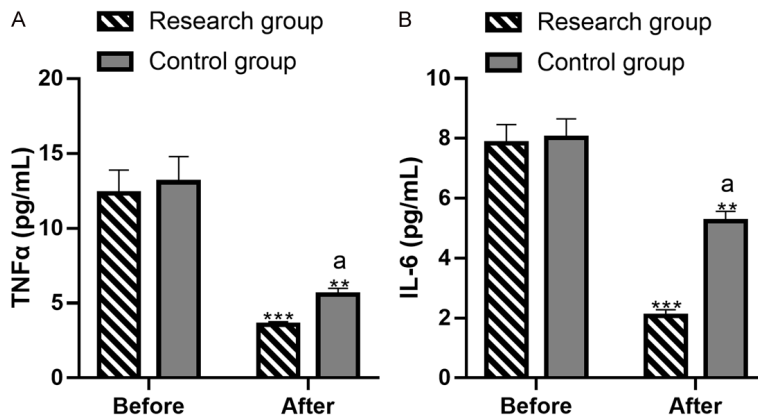
Figure 5. Evaluation of levels of inflammatory cytokines before and after intervention. A: TNFα levels before and after intervention. B: IL-6 levels before and after intervention. Note: **P<0.01 *vs.* before treatment, *** denotes P<0.001 versus before treatment; aP<0.05 *vs.* Control. TNF-α, tumor necrosis factor α; IL-6, interleukin 6.

In this study, ABI scores were evaluated before and after intervention. Both groups showed significant increases in ABI scores after treatment, with a more pronounced improvement in the research group. The analysis of vascular factors indicated a marked increase in VEGF and TGF-β levels after intervention in both groups, particularly in the research group, suggesting that interventional surgery promotes vascular regeneration and protects the vascular endothelium. Measurements of arterial inner diameters showed enlargement of the femoral, popliteal, and dorsalis pedis arteries post-intervention, with larger increases observed in the research group. This indicates that interventional therapy effectively dilates blood vessels and restores vascular function. Additionally, ICK levels, including TNF-α and IL-6, significantly decreased after intervention, especially in the research group, indicating that interventional surgery reduces inflammation and enhances therapeutic efficacy.

The mechanism of interventional surgery for treating PVD in diabetics likely involves the following: First, the use of imaging-guided technology allows for precise localization and treatment of affected areas, significantly improving ABI and alleviating symptoms [31]. Second, this surgical approach protects vascular endothelium, restores vascular function, reduces inflammatory responses, and delivers significant clinical benefits.

This study has certain limitations. First, as a retrospective, single-center study, there may be biases in data collection. Future multicenter prospective studies are needed to mitigate such biases and improve the accuracy of the results. Second, the study lacks a multivariate regression analysis, which would provide valuable insight into additional positive intervention strategies to enhance efficacy. Third, no long-term prognostic analysis was conducted. Follow-up studies should assess the long-term prognosis to better understand the effects and advantages of this treatment. Future research will address these limitations.

In conclusion, interventional surgery for diabetic patients with PVD demonstrates significant clinical advantages, improving treatment efficacy, reducing ICK levels, expanding arterial inner diameters, and enhancing vascular factor levels.

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Disclosure of conflict of interest

None.

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