Am J Transl Res 2025;17(11):9188-9199
www.ajtr.org /ISSN:1943-8141/AJTR0167345

Original Article

Efficacy and safety of bilateral radial versus femoral artery approaches for subclavian artery stenting: a single-center retrospective study

Zezhao Wang[1,3*], Xi Wang[2,3*], Liyuan Zhang[3], Xueji Yu[3], Jie Tang[2], Xiaoyan Dai[4], Tao Qiu[3]

[1]The Affiliated Hospital of North Sichuan Medical College, Nanchong 637000, Sichuan, China; [2]Department of Neurology, The Affiliated Hospital of Southwest Medical University, Luzhou 646000, Sichuan, China; [3]Department of Neurology, Zigong First People's Hospital, Zigong 643000, Sichuan, China; [4]Department of Outpatient, Zigong First People's Hospital, Zigong 643000, Sichuan, China. [*]Equal contributors and co-first authors.

Received July 10, 2025; Accepted November 25, 2025; Epub November 25, 2025; Published November 30, 2025

Abstract: Objective: To compare the efficacy and safety of the bilateral radial artery versus femoral artery approach for subclavian artery stenting. Methods: This retrospective study included 126 patients who underwent subclavian artery stenting at the First People's Hospital of Zigong between January 2019 and December 2024. Patients were divided into a bilateral radial artery group (n=63) and a femoral artery group (n=63). Baseline data, perioperative outcomes, and complications were compared. Effectiveness indicators included procedural success, radiation dose, operative time, postoperative pain score, hospital stay, and total cost. Safety outcomes included composite perioperative events (death, stroke, myocardial infarction, or major bleeding) and puncture site complications. Results: All procedures were successfully completed without conversion. Compared to the femoral approach, the bilateral radial approach was associated with shorter operation time, reduced radiation exposure, lower postoperative pain, shorter postoperative hospital stay, and decreased total hospitalization cost (all P<0.05). No composite endpoint events occurred in either group. Puncture site complications were significantly lower with the bilateral radial approach (4.8% vs. 19.0%, P=0.028). Conclusion: Subclavian artery stenting by the bilateral radial artery approach demonstrates equivalent efficacy and superior safety compared the femoral approach. It offers notable advantages in procedural efficiency, recovery, and cost-effectiveness, representing a feasible and recommendable alternative for clinical practice.

Keywords: Bilateral radial artery approach, subclavian steal syndrome, subclavian artery stenting, interventional complications

Introduction

The subclavian artery is a major vessel supplying blood to the brain and upper limbs. The vertebral arteries arise from the bilateral subclavian arteries and contribute significantly to cerebral perfusion. However, narrowing of the subclavian artery-particularly proximal to the origin of the vertebral artery - is not uncommon in clinical practice. The estimated prevalence of subclavian artery stenosis is approximately 2% in the general population and up to 7% among patients evaluated in vascular laboratories or clinical settings. Atherosclerosis is the predominant cause of this condition [1], which most commonly affects the left side [2]. Subclavian artery stenosis may lead to subclavian steal syndrome, upper limb ischemia, or myocardial ischemia in patients who have undergone coronary artery bypass grafting (CABG) using the internal mammary artery [4, 5].

In 1980, Bachman and Kim first reported successful endovascular treatment for subclavian artery stenosis [6], and subsequent studies have confirmed the high efficacy of endovascular interventions for this condition [7]. Compared to conventional open surgery, subclavian artery stenting achieves a higher success rate with less trauma, and has become the preferred treatment option [3, 8]. The guiding catheter used for stent delivery must accommodate balloon and stent manipulation while allowing

https://doi.org/10.62347/CNQK1280

angiographic positioning. Because the subclavian artery is relatively large in caliber, catheters of 8F or greater are typically required, making the femoral artery the most common access route [9]. However, the transfemoral approach has several drawbacks: patient discomfort due to groin exposure, difficulty in hemostasis, prolonged bed rest, need for urinary catheterization, risk of infection, back pain from immobility, deep vein thrombosis, pseudoaneurysm or hematoma formation, operator fatigue from manual compression, higher device-related costs, and, in rare cases, retroperitoneal hemorrhage. Additionally, iliac or aortic tortuosity, stenosis, or occlusion may hinder procedural success. Radial artery access, which has become standard for coronary intervention [10], offers several advantages, including greater comfort, fewer complications, and the absence of bed rest requirements [11]. Nevertheless, studies directly comparing transradial and transfemoral approaches for subclavian artery stenting remain limited. To address this gap, a novel bilateral transradial approach was developed and implemented at the First People's Hospital of Zigong in 2022 [12]. In this technique, the contralateral radial artery provides angiographic guidance, while the ipsilateral radial sheath serves as the stent delivery route. Clinically, this method demonstrated advantages in procedural simplicity, lower cost, shorter postoperative hospitalization, and improved patient comfort.

In this study, a retrospective analysis was conducted to compare the differences between the radial and femoral artery approaches for subclavian artery stent implantation, in order to support evidence-based clinical practice. The study also aimed to evaluate the advantages of the bilateral radial artery approach in the treatment of subclavian artery stenosis.

Patients and methods

Study design

This retrospective analysis included patients who underwent subclavian artery stent implantation in the Department of Neurology, the First People's Hospital of Zigong, between January 2019 and December 2024. Patients were categorized into two groups based on the access route: the bilateral radial artery approach group and the traditional femoral artery approach group. This study protocol was reviewed and approved by the Ethics Committee of Zigong First People's Hospital.

Inclusion criteria

a. All patients underwent digital subtraction angiography (DSA) before the procedure to confirm the presence of subclavian artery stenosis. b. According to the Chinese Expert Consensus on the Management of Subclavian/Extracranial Vertebral Artery Stenosis, patients with symptomatic subclavian artery stenosis >50% were included if drug therapy was ineffective. Symptoms of posterior circulation ischemia (e.g., dizziness, syncope, vertigo, etc.) and/or upper limb ischemia (e.g., weakness, numbness, etc.) were considered clinical manifestations. c. Patients with asymptomatic subclavian artery stenosis >70% and/or a trans-stenotic systolic pressure gradient ≥20 mmHg were also included. d. Eligible patients were required to have complete medical records and a confirmed diagnosis.

Exclusion criteria

a. Patients with bilateral subclavian artery stenosis. b. Patients requiring simultaneous treatment of other vascular lesions. c. Known allergy to contrast agents, materials, or equipment used in the procedure. d. Presence of intracranial aneurysm. e. Myocardial infarction or large cerebral infarction occurring within the previous 2 weeks. f. Active gastrointestinal bleeding. g. Uncontrolled hypertension. h. Contraindication to heparin, aspirin, or other antiplatelet agents. i. Severe cardiac, hepatic, renal, or pulmonary dysfunction. j. Uncontrolled local or systemic infection at the puncture site. k. Intracranial hemorrhage within the previous 3 months. l. Excessive vascular tortuosity or anatomic variation causing difficulty in advancing delivery systems such as catheters or stents. m. Extensive vascular lesions or large segments of stenosis. n. Stenosis caused by vasculitis or extensive structural vascular abnormalities. o. Thrombosis or severe calcification at the lesion site. p. Coma or severe neurological impairment. q. Incomplete data.

Preoperative preparation

Diagnostic and revascularization criteria

The diagnostic criteria for hemodynamically significant subclavian artery stenosis and the indications for revascularization were established according to the Chinese Expert Consensus on the Management of Subclavian/Extracranial Vertebral Artery Stenosis. Revascularization was recommended for patients meeting the following angiographic criterion and at least one of the subsequent clinical criteria:

a. Angiographic criterion: DSA confirming ≥70% diameter stenosis of the subclavian artery and/or a trans-stenotic systolic pressure gradient of ≥20 mmHg.

b. Clinical criteria (patients must meet at least one of the following):

Symptomatic stenosis: Presence of symptoms related to posterior circulation ischemia (e.g., dizziness, vertigo, syncope) and/or upper limb ischemia (e.g., claudication, numbness, weakness).

Asymptomatic stenosis with any of the following conditions: 1. Planned use of the ipsilateral internal mammary artery for CABG. 2. Previous CABG using the ipsilateral internal mammary artery, with subclavian artery stenosis leading to coronary-subclavian steal syndrome or myocardial ischemia. 3. Hemodialysis patients with an ipsilateral arteriovenous fistula. 4. Bilateral subclavian artery stenosis, preventing accurate assessment of central aortic pressure through brachial blood pressure measurement.

All patients included in this study underwent DSA and met both the angiographic criterion and at least one clinical criterion described above.

Preoperative laboratory examinations - including complete blood count, liver and renal function tests, electrolytes, and coagulation profile - were performed. Electrocardiography, echocardiography, and chest CT or X-ray were also obtained. Dual antiplatelet therapy was administered for at least 3-5 days prior to surgery. For emergency procedures, intravenous tirofiban was administered (0.4 μg/kg for 30 minutes, followed by 0.1 μg/kg for 24-48 hours), overlapping with oral aspirin (100 mg) and clopidogrel (75 mg) initiated 4 hours before discontinuation.

Selection of surgical approach

The choice of surgical approach (bilateral radial or femoral) was determined through shared decision-making between the physician and the patient rather than randomization. The attending physician provided a comprehensive explanation of the advantages and limitations of both approaches. The transfemoral approach was presented as the conventional, well-established method, while the bilateral radial approach was described as a potentially advantageous alternative offering early ambulation and a lower risk of puncture site complications, albeit with certain limitations such as the need for bilateral puncture and possible vascular spasm. The final decision was based on the patient's informed preference, clinical anatomy (e.g., aortic arch type), and the physician's professional judgment. This process reflected real-world clinical practice.

Surgical methods

Femoral artery approach

For patients undergoing the femoral artery approach, preoperative catheterization was performed as follows: a. Local anesthesia was administered at the right femoral artery using 2-5 mL of 5% lidocaine. b. The right femoral artery was percutaneously punctured, and an 8F femoral sheath (Terumo, Japan) was inserted, followed by systemic heparinization. c. An 8F guiding catheter was advanced to the origin of the subclavian artery over a 0.035-inch hydrophilic guidewire and a 5F multi-lumen catheter. d. Angiography was performed through the guiding catheter to determine the appropriate stent size. e. The 0.035-inch guidewire was carefully advanced across the stenotic segment to reach the distal brachial artery. f. If the vessel was severely narrowed, pre-balloon was performed with a balloon catheter before stent placement. If the stent could be passed directly, it was advanced to the lesion site along the 0.035-inch hydrophilic guidewire. After precise angiographic positioning, the stent was deployed by balloon expansion. g. Post-deployment angiography was performed to confirm optimal stent expansion and distal vessel patency. h. Hemostasis was achieved by applying compression using a femoral artery closure device.

Bilateral radial artery approach

The procedure was as follows: a. Local anesthesia was administered to both radial arteries

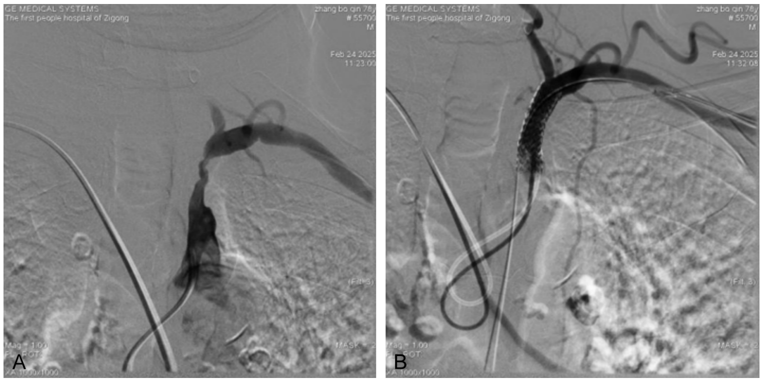

Figure 1. Left-side subclavian artery stent implantation in a 78-year-old male, with a procedure duration of 9 minutes. A. Pre-procedure angiographic image showing the stenosis. B. Post-stent deployment angiographic image demonstrating successful stent placement.

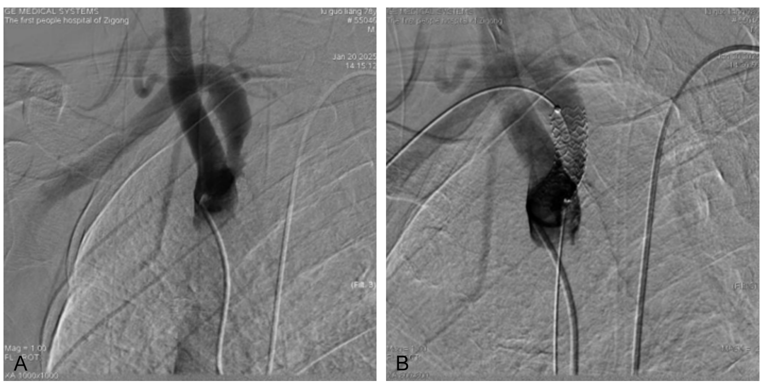

Figure 2. Right-side subclavian artery stent implantation in a 78-year-old-male with a procedure duration of 15 minutes. A. Pre-procedure angiographic image showing the stenosis. B. Post-stent deployment angiographic image demonstrating successful stent placement.

using 1 mL of 5% lidocaine. b. A 6F radial artery sheath was inserted on the affected side and a 5F sheath on the contralateral side. Systemic heparinization was performed, and 200 U of nitroglycerin was administered intra-arterially to prevent vasospasm. c. On the contralateral side of the lesion, a 2.6-meter 0.035-inch hydrophilic guidewire was used to advance a 5F Simmons 2 (SM2) guiding catheter into the aortic arch. After forming a loop, the catheter was maneuvered to selectively engage the subclavian artery on the affected side. d. Angiography was performed through the SM2 catheter to determine the appropriate stent size. e. The 0.035-inch guidewire was carefully advanced across the stenotic segment into the aortic arch. f. If the vessel was severely narrowed, balloon pre-dilation was performed before stent placement. If the stent could pass directly, it was advanced to the lesion site along the 0.035-inch guidewire. After precise positioning under angiographic guidance by the SM2 catheter, the stent was deployed by balloon expansion. g. Post-deployment angiography was conducted to confirm optimal stent configuration and distal vessel patency. h. The arterial sheaths were removed, and both radial arteries were compressed using elastic bandages to achieve hemostasis. Representative procedural steps are shown in **Figures 1** and **2**, and radial artery puncture site hemostasis is illustrated in **Figure 3**.

Observation indicators

Baseline data were collected for both patient groups, including age, sex, smoking status, alcohol consumption, hypertension, diabetes, hyperlipidemia, presence of subclavian steal syndrome, location of stenosis, aortic arch type, and degree of stenosis. Perioperative data were compared between the two groups, encompassing radiation dose, procedural cost, postoperative hospital stay, total hospitalization expense, and surgical complications such as stroke and myocardial infarction. Additional intraoperative indicators included: a. puncture time: defined as the duration from needle insertion to successful sheath placement; b. operation time: defined as the total time from patient entry into the operating room to exit, including preoperative preparation (disinfection and draping) and postoperative hemostasis; c. postoperative pain score: assessed using the Numerical Rating Scale (NRS); and d. puncture-related injuries: including pseudoaneurysm, subcutaneous hematoma, and other local complications. The advantages and disadvantages of the transradial or transfemoral approaches for subclavian artery stenting were thereby evaluated. Data extraction was independently performed by two trained neurologists (Z.W. and

Figure 3. Demonstration of hemostasis at the radial artery puncture site. A. Fold two pieces of gauze into one strip of appropriate width. B. Wrap the needle cap of a 20 mL syringe around the center of the gauze strip to form a gauze roll. C. Apply the gauze roll to compress the puncture site and remove the arterial sheath. D. Secure the compression with an elastic bandage of appropriate tightness. E. The radial artery puncture site is shown with good hemostasis achieved.

X.W.) using a standardized electronic data collection form. Discrepancies were resolved through discussion or, when necessary, adjudication by a senior investigator (T.Q.).

Outcome measures

<u>*Primary outcomes (effectiveness)*</u>

Technical success rate: Defined as successful stent deployment at the target lesion with residual stenosis <30% and without the need for conversion to an alternative access route (e.g., from radial to femoral). Technical success was confirmed immediately after the procedure by final ngiographic assessment.

Incidence of puncture site complications: Defined as the occurrence of any of the following vascular acces-related events within 24 hours after the procedure: major hematoma (requiring blood transfusion or surgical intervention), pseudoaneurysm, arteriovenous fistula, or radial artery occlusion (evaluated by Doppler ultrasonography when clinically indicated).

<u>*Secondary outcomes*</u>

Procedure-related metrics: Puncture time (min): Defined as the duration from local anesthetic administration to successful sheath placement.

Operation time (min): Defined as the total time from patient entry into the operating room to exit after the procedure.

Radiation dose (mGy): Represented by the cumulative air kerma automatically recorded by the angiography system throughout the entire procedure.

Economic and recovery metrics: Surgical cost (CNY) and total hospitalization cost (CNY): Retrieved from the hospital billing system at the time of discharge.

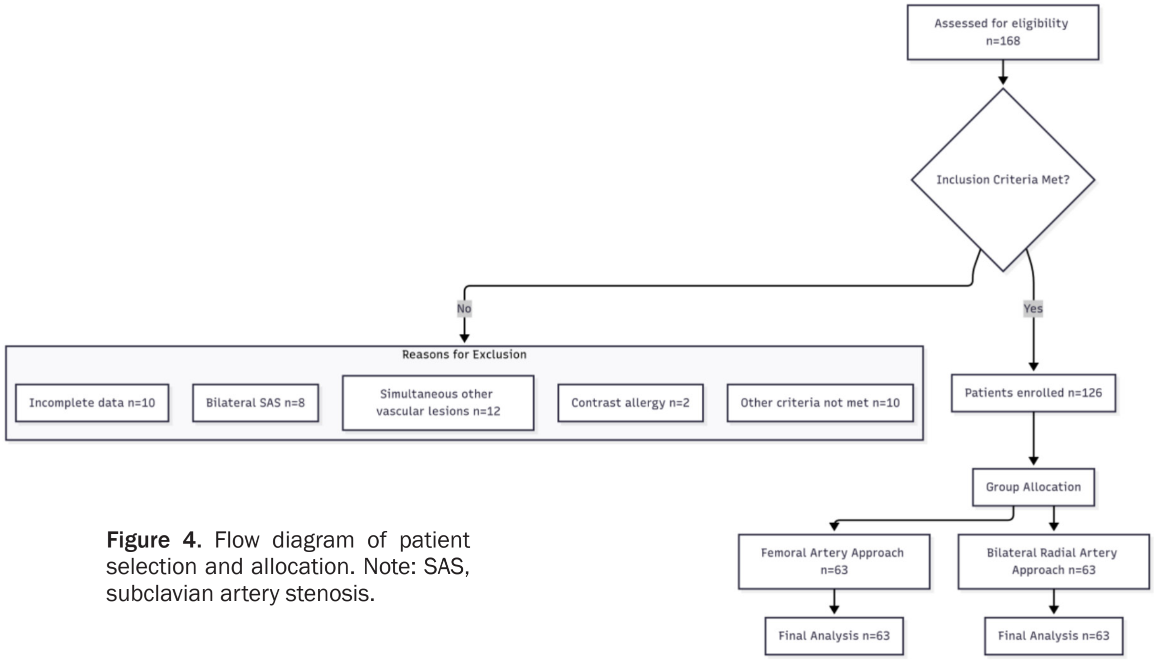

Figure 4. Flow diagram of patient selection and allocation. Note: SAS, subclavian artery stenosis.

Postoperative hospital stay (days) and total hospital stay (days): Calculated based on medical record data after discharge.

Patient comfort and safety: Postoperative pain score: Evaluated using the NRS at the puncture site 6 hours after the procedure.

Incidence of major adverse events: Defined as the occurrence of any of the following events during hospitalization: new-onset stroke, myocardial infarction, or death.

Statistical analysis

All statistical analyses were performed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). Quantitative data were expressed as mean ± standard deviation ($\bar{x} \pm s$), and independent-sample t-tests were used to compare means between groups. Categorical variables were presented as counts and percentages [n (%)], and comparisons were performed using the chi-square (χ^2) test or Fisher's exact test, as appropriate. Multivariate analysis was conducted using logistic regression. A *P* value <0.05 was considered significant.

Results

Patient selection and flow

A total of 168 patients who underwent subclavian artery stenting between January 2019 and December 2024 were initially screened for eligibility. After applying the inclusion and exclusion criteria, 42 patients were excluded for the following reasons: bilateral subclavian artery stenosis (n=8), concomitant vascular lesions requiring simultaneous treatment (n=12), incomplete clinical or imaging data (n=10), contrast agent allergy (n=2), and failure to meet other inclusion criteria (n=10). Consequently, 126 patients were included in the final analysis and categorized into the femoral artery approach group (n=63) and the bilateral radial artery approach group (n=63). The detailed patient flow is illustrated in **Figure 4**. The mean age of patients in the femoral artery group was 64.94±8.34 years, while that of the bilateral radial artery group was 66.46±7.64 years. There were 35 male patients in the femoral artery group and 34 in the bilateral radial artery group. No significant differences were observed in age or sex between the two groups (both P>0.05). Apart from a significantly higher prevalence of hypertension in the femoral artery group compared to the radial artery group (63.5% vs. 44.4%, P=0.049), other demographic and clinical characteristics - including smoking, alcohol consumption, diabetes, hyperlipidemia, subclavian steal syndrome, and lesion location - did not differ significantly between groups (all P>0.05). However, the distribution of aortic arch types differed significantly between the two approaches (P=0.030). The radi-

Table 1. Comparison of demographic and clinical characteristics between the femoral artery group and the bilateral radial artery group [$\bar{x}$ ± s; n (%)]

Variable	Femoral artery group	Bilateral radial artery group	t/χ^2	P
Age (years)	64.94±8.34	66.46±7.64	-1.069	0.287
Sex			0	1
Male	35 (55.6)	34 (54.0)		
Female	28 (44.4)	29 (46.0)		
Smoking	38 (60.3)	33 (52.4)	0.516	0.472
Alcohol consumption	21 (33.3)	16 (25.4)	0.612	0.434
Hypertension	40 (63.5)	28 (44.4)	3.866	0.049*
Diabetes mellitus	21 (33.3)	28 (44.4)	1.202	0.273
Hyperlipidemia	16 (25.4)	21 (33.3)	0.612	0.434
Subclavian steal syndrome	38 (60.3)	28 (44.4)	2.577	0.108
Aortic arch type			6.996	0.030*
Type I	5 (7.9)	13 (20.6)		
Type II	56 (88.9)	44 (69.8)		
Type III	2 (3.2)	6 (9.5)		
Degree of stenosis	0.78±0.13	0.73±0.13	2.093	0.038*
Lesion site			0.046	0.830
Left	50 (79.4)	48 (76.2)		
Right	13 (20.6)	15 (23.8)		

Notes: Data are presented as mean ± standard deviation ($\bar{x}$ ± s) or number (%). P<0.05 indicates statistical significance (P<0.05 = *).

al artery group showed a higher proportion of type I arches (20.6% vs. 7.9%) and a lower proportion of type II arches (69.8% vs. 88.9%). Additionally, the degree of stenosis was less severe in the radial artery group than in the femoral artery group (0.73±0.13 vs. 0.78±0.13, P=0.038). Baseline demographic and clinical data are summarized in **Table 1**.

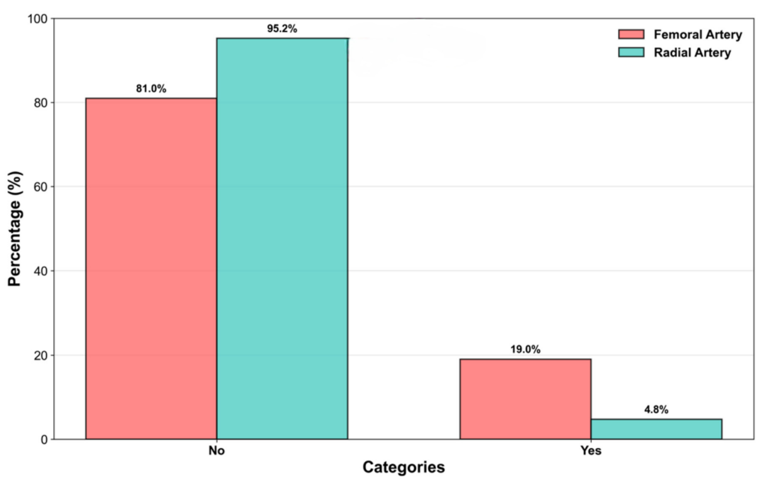

Figure 5. Comparison of the incidence of puncture site complications between the femoral artery and bilateral radial artery groups.

Comparison of primary indexes

In terms of safety assessment, no severe complications such as stroke or myocardial infarction occurred in either group. Regarding puncture site complications, the femoral artery group reported 12 cases (19.0%), whereas the bilateral radial artery group reported 3 cases (4.8%) (P=0.028; **Figure 5**). Thus, complications were significantly higher in the femoral artery group compared to the bilateral radial artery group.

Comparison of secondary indexes

The bilateral radial approach demonstrated significant advantages across multiple procedural, safety, and recovery measures. A comprehensive comparison of secondary indexes between the two groups is presented in **Table 2**.

Table 2. Comparison of postoperative observation indices between the femoral artery group and the bilateral radial artery group [($\bar{x}$ ± s); n (%)]

Variable	Femoral artery group	Bilateral radial artery group	t/χ^2	P
Surgical cost (CNY)	9162.10±2649.27	8591.98±2065.28	1.347	0.180
Total hospitalization cost (CNY)	36,937.34±7,208.11	30,346.45±4,545.06	6.139	<0.001***
Postoperative hospital stay (days)	4.89±3.62	2.33±1.43	5.214	<0.001***
Total hospital stay (days)	11.86±5.37	12.37±6.67	-0.471	0.639
Radiation exposure (mGy)	40.38±28.06	15.84±9.28	6.589	<0.001***
Puncture time (min)	4.45±1.73	7.73±2.47	-8.642	<0.001***
Operation time (min)	62.18±25.90	44.98±19.41	4.217	<0.001***
Postoperative pain score	2.63±1.41	1.94±1.11	3.099	0.002**
(NRS) Incidence of site complications, n (%)	12 (19.0)	3 (4.8)	4.843	0.028*

Note: Data are expressed as mean ± standard deviation ($\bar{x}$ ± s) or number (%). P<0.05 indicates statistical significance (P<0.05 = *, <0.01 = **, <0.001 = ***).

Procedure efficiency: Although the puncture time was longer in the bilateral radial artery group (7.73±2.47 min vs. 4.45±1.73 min, P<0.001), the total operation time was markedly shorter (44.98±19.41 min vs. 62.18±25.90 min, P<0.001), indicating greater overall procedural efficiency once vascular access was established.

Radiation safety: Patients in the bilateral radial artery group received less than half the radiation dose compared to the femoral artery group (15.84±9.28 mGy vs. 40.38±28.06 mGy, P<0.001), representing a 60.8% reduction in exposure.

Economic and recovery benefits: The bilateral radial approach was associated with a 52.4% reduction in postoperative hospital stay (2.33± 1.43 days vs. 4.89±3.62 days, P<0.001) and a 17.8% reduction in total hospitalization cost (30,346.45±4,545.06 CNY vs. 36,937.34± 7,208.11 CNY, P<0.001).

Patient comfort: Postoperative pain scores at the puncture site were significantly lower in the bilateral radial artery group (1.94±1.11 vs. 2.63±1.41, P=0.002).

Multivariable regression analysis

To determine the independent association between the surgical approach and postoperative outcomes, multivariable regression analyses were performed. After adjustment for age, hypertension, aortic arch type, and degree of stenosis, the bilateral radial artery approach remained a significant independent predictor of improved outcome. Results are summarized in **Table 3**. Specifically:

The approach was associated with a substantial reduction in total hospitalization cost (β=-6605.03, 95% confidence interval [CI]: -8795.23 to -4414.84; P<0.001).

It independently predicted a significantly shorter postoperative hospital stay (β=-2.78 days, 95% CI: -3.78 to -1.77; P<0.001).

Most importantly, it was associated with a markedly lower risk of puncture site complications (odds ratio =0.21, 95% CI: 0.05-0.84; P=0.027).

Among the covariates, only older age showed a weak but significant association with longer postoperative hospital stay (β=0.06 days per year; P=0.044). No other covariates demonstrated significant associations in the regression models.

Discussion

Our study demonstrates that endovascular intervention for subclavian artery stenosis is highly effective. Both surgical approaches - the bilateral radial and femoral artery access-achieved a 100% procedural success rate without the need for access conversion, indicating that each approach is a reliable and feasible method for endovascular treatment of subclavian artery stenosis.

According to previous studies [13], patients undergoing radial artery and femoral artery

Table 3. Multivariable regression analyses of factors associated with key outcomes

Variable	Outcome	β/OR (95% CI)	*P* Value
Surgical Approach (Bilateral Radial vs. Femoral)	Total Hospitalization Costs	-6605.03 (-8795.23 to -4414.84)	<0.001
	Postoperative Hospital Stay	-2.78 (-3.78 to -1.77)	<0.001
	Puncture Site Complications	0.21 (0.05 to 0.84)	0.027
Age	Total Hospitalization Costs	134.32 (-1.85 to 270.49)	0.054
	Postoperative Hospital Stay	0.06 (0.00 to 0.13)	0.044
	Puncture Site Complication	0.98 (0.92 to 1.06)	0.656
Hypertension	Total Hospitalization Costs	-182.62 (-2363.0. to 1997.79)	0.869
	Postoperative Hospital Stay	-0.33 (-1.33 to 0.67)	0.511
	Puncture Site Complication	1.05 (0.33 to 3.34)	0.932
Aortic Arch Type	Total Hospitalization Costs	951.66 (-1420.51 to 3323.83)	0.433
	Postoperative Hospital Stay	-0.06 (-1.15 to 1.03)	0.914
	Puncture Site Complication	1.01 (0.24 to 4.31)	0.993
Stenosis Degree	Total Hospitalization Costs	3394.96 (-4701.63 to 11491.55)	0.413
	Postoperative Hospital Stay	-1.10 (-4.81 to 2.61)	0.563
	Puncture Site Complication	0.49 (0.01 to 36.67)	0.744

Abbreviations: CI, confidence interval; OR, odds ratio. Linear regression was used for total hospitalization costs and postoperative hospital stay (reported as β coefficient). Logistic regression was used for puncture site complications (reported as OR). All models were adjusted for all variables listed in the table.

interventions receive comparable radiation doses, whereas other reports [14] have shown that femoral artery coronary angiography is associated with higher patient radiation exposure. Our earlier single-center experience with cerebral angiography by the radial and femoral approaches also suggested that both routes require similar procedural times and radiation doses, as the fundamental operational steps are largely consistent despite the different access route. However, our current study revealed a significant difference in radiation exposure between the two approaches. Subgroup analysis demonstrated that right subclavian artery stenting performed through the femoral approach, particularly in patients with type III aortic arches, required significantly longer procedural times due to the technical difficulty of navigating the vascular pathway. In contrast, the bilateral radial artery approach yielded comparable procedural durations regardless of laterality. Shorter operation times and reduced radiation exposure may, in turn, lower the risk of adverse reactions such as contrast-induced allergy or contrast-induced encephalopathy. Regarding puncture time, the femoral artery is relatively large and easily palpable, making puncture more straightforward, whereas the radial artery has a smaller caliber and requires bilateral puncture, resulting in a longer puncture time.

In this study, patients in the bilateral radial artery group had shorter postoperative hospital stays and lower total hospitalization costs compared to those in the femoral artery group. In clinical practice, when procedures proceed uneventfully, the radial artery approach typically requires only an additional radial sheath and a 5F SM2 angiographic catheter, while the materials needed for bilateral radial artery hemostasis are minimal. By contrast, the femoral artery approach requires an additional 8F guiding catheter, a 5F multifunctional catheter, and a femoral artery closure device, which costs approximately RMB 1,000. Overall, these additional consumables increase the procedural material cost of the femoral approach by roughly RMB 1,500 t compared to the radial approach.

Postoperative hospital stay was significantly shorter in patients treated by the bilateral radial artery approach. This finding is consistent with results reported in both the coronary intervention field [15] and neurointerventional practice. Imahori et al. [16] similarly demonstrated shorter hospital stays among patients who underwent carotid artery stenting through the transradial route. Following femoral artery access, patients are typically required to remain immobilized for an extended period, which may worsen postoperative quality of life due to prolonged bed rest. Noncompliance with postoperative instructions, or other factors, may result in hematoma or pseudoaneurysm formation at the puncture site. Additionally, sustained lower-limb compression during immobilization increases the risk of deep vein thrombosis, all of which contribute to prolonged hospitalization. In contrast, patients who underwent bilateral radial artery puncture did not require bed rest, allowing earlier ambulation and faster wound recovery, thereby shortening postoperative hospital stay. However, no significant difference was observed in the total duration of hospitalization between the femoral and radial groups. This discrepancy may be attributed to the retrospective nature of the study. Most patients who underwent femoral artery access were treated earlier in the study period, when diagnostic angiography and stenting were often performed during the same session. Because patients are typically reluctant to undergo a second femoral puncture, stent placement was frequently completed concurrently using angiography. Conversely, patients who underwent angiography through the radial artery generally had better perioperative preparation, often receiving dual antiplatelet therapy for 3-5 days prior to intervention.

The femoral artery is located in the inguinal region, which is rich in both vascular and neural structures. In contrast, the radial artery puncture site lacks major veins and nerves, making nerve injury or ischemic pain far less likely. No new deaths, strokes, myocardial infarctions, or major bleeding events occurred in either group, indicating that both surgical approaches are safe. In this study, puncture site complications were significantly less frequent in the bilateral radial artery group than in the femoral artery group. Previous studies of interventional therapy for ST-segment elevation myocardial infarction [17] have similarly shown a lower incidence of access-site complications in the radial approach compared to the femoral approach. This advantage is largely attributable to the superficial location of the radial artery, where minimal soft tissue coverage at the wrist allows rapid detection and effective compression of hematomas, thereby reducing postoperative bleeding and related complications. Color Doppler ultrasonography performed within 24 hours postoperatively revealed an extremely low incidence of hematoma at the puncture site in both groups.

The bilateral radial artery approach offers several distinct advantages: 1. Enhanced patient comfort: Patients do not require urinary catheterization and are able to ambulate immediately after the procedure, which significantly improves postoperative comfort and satisfaction. 2. Technical feasibility: In cases of right subclavian artery stenosis accompanied by a Type III aortic arch, it is often technically challenging to advance guidewires and catheters from the femoral artery to the right subclavian artery, which may prolong the procedure or even prevent its completion. In contrast, access via the left radial artery allows straightforward advancement of the stent to the target lesion. Similarly, for left subclavian artery stenosis near the aortic origin, stable positioning of guidewires and catheters through the femoral route can be difficult, making stent delivery unreliable. The left radial artery approach facilitates smoother navigation and more accurate stent placement in such cases.

Despite its advantages, the radial artery approach for subclavian artery stent implantation has certain limitations: 1. Bilateral puncture requirement: The procedure requires simultaneous puncture of both radial arteries. Failure of puncture on either side can hinder surgical progress. Radial artery spasm or other puncture-related issues may also lead to procedural failure, with the incidence of radial artery spasm reported to be as high as 51.3% [18]. 2. Anatomic constraints: Patients with chronic subclavian artery occlusion, excessive angulation between the two subclavian arteries, or significant bilateral radial artery stenosis are generally unsuitable for bilateral radial artery intervention. 3. Device delivery limitations: The radial approach permits only the passage of bare stents through the radial artery sheath. Most radial arteries can accommodate a maximum of a 6F sheath, restricting the diameter of deliverable subclavian stents to ≤10 mm. Stents exceeding this diameter are difficult to advance. Furthermore, balloon-expandable stents may pose a risk of dislodgement during delivery due to the longer segment extending beyond the delivery catheter. However, based on our experience, a 10 mm stent can still be delivered through a 6F sheath with mild resistance and without detachment. Once the stent exits the sheath, it can be smoothly advanced through the radial, brachial, and subclavian arteries with minimal risk of separation. In contrast, self-expanding stents can be delivered more easily owing to their smooth outer delivery sheath. 4. Radial artery occlusion: The incidence of radial artery occlusion following radial access is approximately 2.3% [19] in conventional sheath groups. Nevertheless, this condition is typically asymptomatic due to the extensive collateral circulation of the hand.

Limitations

This study has several limitations inherent to its retrospective design. First, selection bias may exist, as preference for the bilateral radial artery approach likely increased over time with growing operator proficiency. Second, the sample size, although adequate for evaluating primary outcomes, remained relatively modest and originates from a single center, which may have limited the generalizability of the findings. Therefore, future prospective, multicenter studies with larger cohorts are warranted to validate and expand upon our results.

In addition to the inherent constraints of its retrospective design, several other caveats warrant consideration. First, the single-center nature of this study may limit the generalizability of its findings, as patient demographics, operator experience, and perioperative management protocols can differ across institutions. Second, although the sample size was sufficient to detect differences in primary outcomes, it was relatively modest, which limited the power to perform detailed subgroup analyses (e.g., stratified by aortic arch type or stenosis etiology) and to evaluate very rare adverse events. Third, this study primarily focused on short-term perioperative outcomes. Long-term data on stent patency, radial artery occlusion, and recurrence of clinical symptoms are essential for a comprehensive assessment of the bilateral radial approach but were beyond the scope of this analysis. Future prospective, multicenter studies with larger sample sizes and extended follow-up periods are needed to validate these findings.

Conclusion

The bilateral radial artery approach for vascular interventional therapy is both safe and effective for treating subclavian artery stenosis. Compared to the femoral artery approach, the radial artery route offers several advantages, including shorter operation time, reduced radiation exposure, shorter postoperative hospital stays, lower hospitalization costs, fewer puncture site complications, and higher patient comfort. Additionally, the bilateral radial artery approach proves particularly beneficial for patients with Type III aortic arches and left subclavian artery stenosis at the aortic origin. With thorough preoperative preparation, the bilateral radial artery approach should be promoted for subclavian artery stent implantation.

Disclosure of conflict of interest

None.

Address correspondence to: Tao Qiu, Department of Neurology, Zigong First People's Hospital, Zigong 643000, Sichuan, China. Tel: +86-08132109372; E-mail: qiutao_zgyyy@163.com; Xiaoyan Dai, Department of Outpatient, Zigong First People's Hospital, Zigong 643000, Sichuan, China. Tel: +86-08132109372; E-mail: dxy_zgyyy@163.com

References

[1] Iared W, Mourao JE, Puchnick A, Soma F and Shigueoka DC. Angioplasty versus stenting for subclavian artery stenosis. Cochrane Database Syst Rev 2014; 2014: CD008461.

[2] Sahsamanis G, Vourliotakis G, Pirgakis K, Lekkas A, Kantounakis I, Terzoglou A and Tzilalis V. Primary stenting of right-sided subclavian artery stenosis presenting as subclavian steal syndrome: report of 3 cases and literature review. Ann Vasc Surg 2018; 48: 254.e251-254.e255.

[3] Liang S, Zhang A, Li F, Xia Y, Feng G, Xu B and Wang H. Clinical study of 57 cases of endovascular treatment for total subclavian artery occlusion. Vascular 2025; 33: 556-566.

[4] Van Nut L, Vinh PX and Vuong NL. Endovascular treatment for subclavian artery stenosis and occlusion: a single-center retrospective study. Cureus 2023; 15: e44699.

[5] Rafailidis V, Li X, Chryssogonidis I, Rengier F, Rajiah P, Wieker CM, Kalva S, Ganguli S and Partovi S. Multimodality imaging and endovascular treatment options of subclavian steal syndrome. Can Assoc Radiol J 2018; 69: 493-507.

[6] Bachman DM and Kim RM. Transluminal dilatation for subclavian steal syndrome. AJR Am J Roentgenol 1980; 135: 995-996.

[7] Yang SJ, Gu YQ, Luo T, Qi LX, Zhang CC, Tong Z, Wang DS and Wu ZJ. Left subclavian artery stenosis treated with covered stent. J Biol Regul Homeost Agents 2019; 33: 1875-1878.

[8] Krishnappa S, Rachaiah JM, Hegde SS, Sadananda KS, Nanjappa MC and Ramasanjeevaiah G. Percutaneous antegrade and retrograde endovascular approach to symptomatic high-grade subclavian artery stenosis: technique and follow-up. Heart Views 2019; 20: 87-92.

[9] Appleby BS and Kelso R. Subclavian steal syndrome presenting as a reversible dementia. J Neuropsychiatry Clin Neurosci 2015; 27: e74-75.

[10] Roy S, Kabach M, Patel DB, Guzman LA and Jovin IS. Radial artery access complications: prevention, diagnosis and management. Cardiovasc Revasc Med 2022; 40: 163-171.

[11] Gargiulo G, Giacoppo D, Jolly SS, Cairns J, Le May M, Bernat I, Romagnoli E, Rao SV, van Leeuwen MAH, Mehta SR, Bertrand OF, Wells GA, Meijers TA, Siontis GCM, Esposito G, Windecker S, Juni P and Valgimigli M; Radial Trialists' Collaboration. Effects on mortality and major bleeding of radial versus femoral artery access for coronary angiography or percutaneous coronary intervention: meta-analysis of individual patient data from 7 multicenter randomized clinical trials. Circulation 2022; 146: 1329-1343.

[12] Qiu T, Fu SQ, Deng XY, Chen M and Dai XY. Subclavian artery stenting via bilateral radial artery access: four case reports. World J Clin Cases 2022; 10: 1747-1753.

[13] Oren O, Oren M and Turgeman Y. Transradial versus transfemoral approach in peripheral arterial interventions. Int J Angiol 2016; 25: 148-152.

[14] Gurajala V, Daruru C, Narayanan K and Sridhar L. Comparison of patient radiation exposure in coronary angiography via the trans-radial versus trans-femoral approach. Indian Heart J 2025; 77: 28-35.

[15] Almeida AS, Fuchs SC, Fuchs FC, Silva AG, Lucca MB, Scopel S and Fuchs FD. Effectiveness of clinical, surgical and percutaneous treatment to prevent cardiovascular events in patients referred for elective coronary angiography: an observational study. Vasc Health Risk Manag 2020; 16: 285-297.

[16] Imahori T, Miyake S, Maeda I, Goto H, Nishii R, Enami H, Yamamoto D, Harada T, Tanaka J, Sakata J, Hamaguchi H, Sakai N, Sasayama T and Hosoda K. Clinical outcomes of shifting from transfemoral-first to transradial-first approach in carotid artery stenting: a retrospective two-timeframe comparison at a single center. J Clin Med 2024; 13: 7432.

[17] Malik AH, Yandrapalli S, Shetty SS, Zaid S, Athar A, Aronow WS, Timmermans RJ, Ahmad H, Cooper HA, Naidu SS and Panza JA. Radial vs. femoral access for percutaneous coronary artery intervention in patients with ST-elevation myocardial infarction. Cardiovasc Revasc Med 2021; 28: 57-64.

[18] Zus AS, Crisan S, Luca S, Nisulescu D, Valcovici M, Patru O, Lazar MA, Vacarescu C, Gaita D and Luca CT. Radial artery spasm-a review on incidence, prevention and treatment. Diagnostics (Basel) 2024; 14: 1897.

[19] Hashmi KA, Iqbal Z, Hashmi AA, Shoaib M, Irfan M, Khan R, Ali N, Khan A and Edhi MM. The frequency of radial artery occlusion following cardiac catheterization with the use of transradial pneumatic compression band. BMC Res Notes 2020; 13: 486.