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Article

Evaluation of the Safety and Efficacy of Coronary Intervention through the Brachial Artery Compared to the Radial Artery in Elderly Patients with Different Extubation Times

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Abstract

Introduction: Percutaneous coronary intervention (PCI) is an important treatment for acute coronary syndrome. The main puncture paths of PCI include radial artery, brachial artery, and femoral artery. The aim of this study was to investigate the safety and efficacy of transbrachial intervention in elderly patients. **Methods**: According to intraoperative and postoperative nursing records, a retrospective analysis was performed for 70 elderly patients who underwent coronary intervention were divided into brachial artery A group (33 cases) and brachial artery B group (37 cases) according to immediate postoperative extubation compression dressing and 6 hours postoperative extubation compression dressing, and matched elderly patients who had successful transradial artery puncture in the same period as radial artery group (35 cases). The success rate of puncture and catheterization, arterial puncture time, total operation time, length of hospital stay, patient comfort score, incidence of arterial spasm and occlusion, subcutaneous ecchymosis and hematoma, epidermal blister occurrence, vagal reflex, pseudoaneurysm development, arteriovenous fistula formation, nerve damage risk assessment and osteofascial compartment syndrome were compared. **Results**: Compared with the radial artery group, the brachial artery group (group A and group B) had a higher success rate of puncture and catheterization (97.0% *vs.* 97.3% *vs.* 80.0%, p = 0.013), shorter arterial puncture time (2.45 ± 0.38 *vs.* 2.40 ± 0.35 *vs.* 3.40 ± 0.37, p = 0.000), and lower incidence of arterial spasm (0.0% *vs.* 0.0% *vs.* 34.3%, p = 0.000), arterial occlusion (0.0% *vs.* 0.0% *vs.* 14.3%, p = 0.005) and puncture site bleeding (12.1% *vs.* 5.6% *vs.* 40.0%, p = 0.001). The incidence of epidermal blister was higher in brachial artery A group than in brachial artery B group (24.2% *vs.* 2.7%, p = 0.003) or radial artery group (24.2% *vs.* 0%, p = 0.001), and the incidence of epidermal blister in brachial artery B group and radial artery group was not much different. There was no difference between the three groups in total operation time, length of hospital stay, comfort score, subcutaneous ecchymosis and hematoma, vagal reflex, pseudoaneurysm, arteriovenous fistula, nerve damage and osteofascial compartment syndrome. **Conclusion**: In elderly patients, coronary intervention through brachial artery is not inferior to radial artery.

Keywords

brachial artery puncture; radial artery puncture; coronary intervention; security; effectiveness

Introduction

Percutaneous coronary intervention (PCI) is an important treatment for acute coronary syndrome [1]. The main puncture paths of PCI include radial artery, brachial artery and femoral artery. The advantages of radial artery puncture are less vascular complications, no absolute limitation of activity, and good comfort [2]. However, in clinical practice, there are often patients presenting with slender and deformed radial arteries that are prone to spasm, stenosis, occlusion, and other conditions. Consequently, these patients face challenges in completing radial artery puncture procedures, particularly the elderly population. The incidence of radial artery occlusion in patients gradually increases with repeated or multiple intervention treatments. Furthermore, the elderly individual exhibit reduced activity levels along with loose subcutaneous tissue around the wrist area and thin skin layers which result in poor arterial support, consequently exacerbating the difficulty of puncture [3]. The femoral artery puncture procedure is associated with prolonged bed rest and a high incidence of venous thrombosis. Some patients may have difficulty tolerating extended periods of immobilization, posing challenges in their care management due to limb movement disorders. Common complications include occlusion of the iliac artery, aortic dissection, pseudoaneurysm formation, and arteriovenous fistula development [4]. Common complications associated with brachial artery puncture include cutaneous blisters, localized hematoma, pseudoaneurysm formation, and median nerve injury. The utilization of brachial artery puncture in

PCI is currently infrequent. When bilateral radial arteries encounter difficulties during passage, the majority of interventional physicians still favor the conventional femoral artery puncture approach [5]. Based on the limitations associated with radial and femoral artery puncture, it is imperative to investigate the safety and efficacy of brachial artery puncture. Since June 2021, percutaneous coronary intervention (PCI) has been successfully performed using brachial artery puncture in elderly patients who are unable to undergo bilateral radial artery puncture guidewire insertion in our hospital. Coronary intervention through the brachial artery is not inferior to that through the radial artery in elderly patients. The removal of the brachial artery sheath 6 hours after surgery is more effective and safer than immediate removal. The characteristic of this study is the removal of the sheath 6 hours after surgery, which has not been extensively studied by scholars in the past. Encouraging outcomes have been observed. Consequently, we present the following report.

Materials and Methods

General Information

From June 2021 to March 2023, 70 elderly patients (39 males and 31 females) with bilateral radial artery occlusion who underwent PCI via brachial artery approach due to failed puncture of bilateral radial artery or multiple coronary interventions in Beijing Aerospace General Hospital Hospital were retrospectively analyzed. The mean age was 74.64 ± 8.89 years (range, 70–98 years). The patients were divided into brachial artery group A (n = 33) and brachial artery group B (n = 37) according to perioperative nursing records and 35 elderly patients with successful transradial puncture at the same period were matched for control evaluation. The three patient groups were administered a preoperative dose of 300 mg aspirin (HJ20160685, Bayer Health Care Manufacturing S .r .I, Guangzhou, China) + 300 mg clopidogrel (HJ20171237, Sanofi Winthrop Industrie, Orleans, France) /180 mg ticagrelor (J20130020, AstraZeneca Pharmaceuticals Limited, Macclesfield, Britain), either intravenously or after the successful insertion of an IV catheter, followed by a standard heparin (H20153264, Hebei Kaiwei Pharmaceutical company of limited, Zhangjiakou, China) injection of 100 iu/kg. The dressing process for all patients undergoing puncture and catheterization is supervised by a skilled physician to ensure professional intervention. The procedures of puncture, catheterization and dressing of all enrolled patients were fixed and operated by an experienced professional interventional doctor.

Methods

Brachial Artery Puncture

The brachial artery pulse, located approximately 0.5–1 cm above the elbow crease, was punctured using a modified Selding's technique with a 6F, 20G radial artery needle (Tiandi Hexie Technology Co.,Ltd., Beijing, China) inserted at an angle of 30–45 degrees from the skin surface. After the blood was spurted from the needle tail, it was directed into the straight head guide wire via the needle core and subsequently delivered through the wire to the 6F radial artery sheath tube. Bandaging: The sheath tube was removed immediately or after 6 hours, and the gauze was pressed for 15 minutes, after which pressure was applied with an elastic bandage. The bandage was released once every 2 hours to ensure the palpability of the brachial artery and prevent bleeding at the puncture site during patient coughing. Remove the pressure dressing after 12 hours.

Radial Artery Puncture

A 6F, 20G radial artery needle was used to puncture the most obvious pulsation of the radial artery within 2 to 4 cm distal to the wrist crease by modified Selding's method, and the needle was inserted at 30–45 degrees from the skin. The blood was spurted from the needle tail, and once the needle core is removed, a straight head guide wire is inserted. Finally, a steel wire is threaded through a 6F arterial sheath pipe. Bandaging: The sheath tube was promptly removed post-operation, and a wrist pressor was utilized to apply pressure dressing. The bandage was released once every 2 hours to ensure the presence of radial artery pulsation and absence of bleeding at the puncture site upon patient coughing. After a duration of 12 hours, the pressure dressing was subsequently removed.

Evaluation Index

The success rate of puncture catheterization, arterial puncture time, total operation time, length of hospital stay, patient comfort score, incidence of arterial spasm and occlusion, subcutaneous ecchymosis and hematoma, epidermal blister occurrence, vagal reflex, pseudoaneurysm development, arteriovenous fistula formation, nerve damage risk assessment and osteofascial compartment syndrome were compared among the three groups of PCI patients. The above indicators were jointly recorded by intraoperative catheterization nurses, postoperative responsible nurses, and PCI follow-up nurses. The definition of successful puncture entails achieving a successful puncture at one skin site and the insertion of an artery sheath tube simultaneously, with unobstructed blood flow. The patient comfort score was assessed using a numeric grading method, with the degree of comfort ranging from 0 to 10 points. A score of zero indicated the worst possible discomfort, while

Table 1. Comparison of general information among three groups.

	Brachial artery A group	Brachial artery B group	Radial artery group	χ^2/F	p value
Gender (male)	16 (48.5)	23 (62.2)	19 (54.3)	1.339	0.512
Age (years)	75.79 ± 8.89	73.54 ± 17.01	76.63 ± 7.07	0.641	0.529
Drinking history consumption	1 (3.0)	5 (13.9)	5 (14.3)	2.914	0.233
Smoking history	15 (45.5)	11 (29.7)	16 (45.7)	2.511	0.285
Hypertension history	22 (66.7)	27 (73.0)	26 (74.3)	0.550	0.760
Diabetes mellitus history	14 (42.4)	9 (24.3)	17 (48.6)	4.866	0.088
LDL-C (mmol/L)	2.49 ± 0.78	2.54 ± 1.43	2.07 ± 0.66	2.057	0.133
LVEF (%)	57.75 ± 11.35	62.70 ± 6.88	60.60 ± 13.30	1.275	0.286

LDL-C, low density lipoprotein cholesterol; LVEF, left ventricular ejection fraction.

Table 2. Evaluation of effectiveness among three groups.

	Brachial artery A group	Brachial artery B group	Radial artery group	χ^2/F	p value
The success rate of puncture and catheterization (%)	32 (97.0)	36 (97.3)	28 (80.0)	8.752	0.013*
Arterial puncture time (min)	2.45 ± 0.38	2.40 ± 0.35	3.40 ± 0.37	30.754	0.000*
Total operation time (min)	39.07 ± 13.04	39.00 ± 13.41	41.21 ± 12.69	0.130	0.878
Length of hospital stay (d)	5.60 ± 2.32	4.90 ± 1.79	5.45 ± 2.54	0.271	0.765
Comfort score	6.50 ± 1.43	6.54 ± 1.37	6.45 ± 1.36	0.012	0.988

*$p < 0.05$ indicates that differences were statistically significant.

a score of ten represented optimal levels of comfort and pleasure. Patients evaluated their own subjective feelings within 12 hours after treatment for puncture wounds following surgery.

Statistical Methods

SPSS 21.0 software (IBM Corp., Armonk, NY, USA) was utilized for conducting statistical analysis. The measurement data were presented as mean ± standard deviation, and comparisons among the three groups were performed using one-way analysis of variance (ANOVA). The count data were expressed as percentages, and comparisons among the three groups were conducted using chi-square test. Additionally, multiple comparisons after ANOVA or chi-square test were carried out using the Bonferroni method. $p < 0.05$ was considered statistically significant.

Results

Comparison of Clinical Data

A retrospective analysis was conducted on a total of 105 PCI patients, comprising 33 patients in brachial artery A group, 37 patients in brachial artery B group, and 35 patients in radial artery group. The results indicated that there were no statistically significant differences in age, gender, drinking history, smoking history, hypertension history, diabetes mellitus history, low-density lipoprotein-cholesterol (LDL-C) levels and left ventricular ejection fraction (LVEF)% among the three groups ($p > 0.05$). The detailed clinical data could be found in Table 1.

Evaluation of Effectiveness

In the three groups, brachial artery puncture was unsuccessful in two patients due to failed attempts, one patient experienced trauma in the right upper limb, and another patient had sequelae of cerebral infarction resulting in impaired smooth abduction of the right upper limb. Additionally, there were eight cases of radial artery puncture failure. The success rate of brachial artery puncture and catheterization (group A and group B) exceeded that of radial artery (97.0% *vs.* 97.3% *vs.* 80.0%, p = 0.013), while the brachial artery puncture time was shorter (2.45 ± 0.38 *vs.* 2.40 ± 0.35 *vs.* 3.40 ± 0.37, p = 0.000), and these differences were statistically significant ($p < 0.05$). The success rate of puncture and catheterization and arterial puncture time showed no significant difference between brachial artery A group and brachial artery B group. Additionally, there were no notable differences observed among the three groups in terms of total operation time, length of hospital stay and comfort score. The information could be found in Tables 2,3.

Evaluation of Safety

In the brachial artery A group, there were 4 cases of puncture site hemorrhage, 7 cases of subcutaneous congestion, 2 cases of subcutaneous hematoma, 8 cases of epidermal bullae, 1 case of vagal reflex, and 1 case of pseudoaneurysm. In the brachial artery B group, there were 2 cases of puncture site hemorrhage, 3 cases of subcutaneous congestion, 1 case of subcutaneous hematoma, and 1 case of epidermal blister. In the radial artery group, there were 12 cases of instances of arterial spasm, 5 cases of arterial oc-

Table 3. The post-hoc multiple comparisons.

	Group 1	Group 2	χ^2/F	p value
The success rate of puncture and catheterization (%)	Brachial artery A group (32/33)	Brachial artery B group (36/37)	0.000	1.000
	Brachial artery A group (32/33)	Radial artery group (28/35)	–0.170	0.035*
	Brachial artery B group (36/37)	Radial artery group (28/35)	–0.170	0.025*
Arterial puncture time (min)	Brachial artery A group (2.45 ± 0.38)	Brachial artery B group (2.40 ± 0.35)	0.314	0.756
	Brachial artery A group (2.45 ± 0.38)	Radial artery group (3.40 ± 0.37)	–6.275	0.000*
	Brachial artery B group (2.40 ± 0.35)	Radial artery group (3.40 ± 0.37)	–7.265	0.000*

*$p < 0.05$ indicates that differences were statistically significant.

Table 4. Evaluation of safety among three groups.

	Brachial artery A group	Brachial artery B group	Radial artery group	χ^2	p value
Arterial spasm	0	0	12 (34.3)	27.097	0.000*
Arterial occlusion	0	0	5 (14.3)	10.500	0.005*
Puncture site bleeding	4 (12.1)	2 (5.6)	14 (40.0)	15.128	0.001*
Subcutaneous ecchymosis	7 (21.2)	3 (8.1)	6 (17.1)	2.466	0.291
Subcutaneous hematoma	2 (6.1)	1 (2.7)	5 (14.3)	3.595	0.166
Epidermal blister	8 (24.2)	1 (2.7)	0	15.249	0.000*
Vagal reflex	1 (3.0)	0	0	2.203	0.332
Pseudoaneurysm	1 (3.0)	0	0	2.203	0.332
Arteriovenous fistula	0	0	0		
Nerve damage	1 (3.0)	0	0	2.203	0.332
Osteofascial compartment syndrome	0	0	0		

*$p < 0.05$ indicates that differences were statistically significant.

clusion, 8 cases of occurrences of bleeding at the puncture site, 6 cases of incidents of subcutaneous congestion, and 5 cases of subcutaneous hematoma. In the artery group, 1 case of median nerve injury was observed, with no significant recovery noted at the 3-month follow-up.The incidence of arterial spasm (0.0% *vs*. 0.0% *vs*. 34.3%, p = 0.000), arterial occlusion (0.0% *vs*. 0.0% *vs*. 14.3%, p = 0.005), and puncture site bleeding (12.1% *vs*. 5.6% *vs*. 40.0%, p = 0.001) in the brachial artery group (group A and group B) is lower than that in the radial artery group. Brachial artery A Group demonstrated a higher incidence of epidermal blisters than both brachial artery B Group (24.2% *vs*. 2.7%, p = 0.003) and the radial artery group (24.2% *vs*. 0%, p = 0.001). There was no significant difference in the incidence of epidermal blisters between the brachial artery B group and the radial artery group. There was no difference among the three groups in terms of subcutaneous ecchymosis, subcutaneous hematoma, vagal reflex, pseudoaneurysm and arteriovenous fistula, nerve damage, and osteofascial compartment syndrome. The information could be found in Tables 4,5.

Discussion

The study conducted by Cui *et al*. [6] demonstrated a 100% success rate for percutaneous brachial artery puncture and percutaneous brachial artery PCI procedures. They further suggested that in cases where femoral access is not available or the radial artery is small or absent, utilizing brachial artery puncture approach can serve as a viable rescue option. The study conducted by Alvarez-Tostado *et al*. [7] revealed a remarkable success rate of 99.6% for the percutaneous brachial artery puncture technique, making it particularly indispensable for individuals encountering difficulties in catheter placement via the femoral artery. The findings of Shinozaki *et al*.'s [8] study on coronary intervention in elderly patients revealed that brachial artery puncture exhibited a significantly shorter average puncture time compared to radial artery puncture, along with a lower incidence of spasm. These results suggest that brachial artery puncture can be considered as the preferred vascular puncture site. The above conclusions are consistent with the present study.

Kennedy *et al*. [9] demonstrated that the incidence of median nerve injury resulting from brachial artery puncture ranged from 0.2–1.4%. In this study, one case of nerve injury occurred in the group undergoing brachial artery puncture, which was attributed to local bleeding at the puncture site after immediate removal of the catheter, inadequate pressure bandaging, and direct compression of the median cubital nerve following formation of a medial brachial artery interfascial septal hematoma. In this study, no instances of nerve injury were observed in either the radial artery puncture group or the brachial artery B group. The sample size of this study was limited, the incidence of nerve injury was relatively low, and the difference was not statis-

Table 5. The post-hoc multiple comparisons.

	Group 1	Group 2	χ^2	*p* value
Arterial spasm	Brachial artery A group (0/33)	Brachial artery B group (0/37)	0.00	1.000
	Brachial artery A group (0/33)	Radial artery group (12/35)	–0.34	0.000*
	Brachial artery B group (0/37)	Radial artery group (12/35)	–0.34	0.000*
Arterial occlusion	Brachial artery A group (0/33)	Brachial artery B group (0/37)	0.00	1.000
	Brachial artery A group (0/33)	Radial artery group (5/35)	–0.14	0.015*
	Brachial artery B group (0/37)	Radial artery group (5/35)	–0.14	0.012*
Puncture site bleeding	Brachial artery A group (4/33)	Brachial artery B group (2/37)	0.07	1.000
	Brachial artery A group (4/33)	Radial artery group (14/35)	–0.28	0.007*
	Brachial artery B group (2/37)	Radial artery group (14/35)	–0.34	0.000*
Epidermal blister	Brachial artery A group (8/33)	Brachial artery B group (1/37)	0.22	0.003*
	Brachial artery A group (8/33)	Radial artery group (0/35)	0.24	0.001*
	Brachial artery A group (1/37)	Radial artery group (0/35)	0.03	1.000

*$p < 0.05$ indicates that differences were statistically significant.

tically significant. Arterial spasm is a significant complication commonly observed in coronary interventional therapy. Research conducted by Roy *et al*. [10] demonstrated that the incidence of radial artery spasm ranged from 4% to 20%. The occurrence of arterial spasm was found to be associated with the vascular sheath diameter exceeding that of the artery, and it was noted that the brachial artery approach exhibited an absolute advantage over the radial artery approach.

The incidence of vascular complications, such as arterial spasm, arterial occlusion, and puncture site bleeding, was found to be higher in the radial artery group compared to the brachial artery group. Additionally, a higher occurrence of epidermal blisters was observed in A Group (brachial artery puncture) than in B Group. However, there were no significant differences among the three groups regarding subcutaneous congestion, subcutaneous hematoma, pseudoaneurysm formation or arteriovenous fistula development. These findings were inconsistent with previous studies conducted both domestically and internationally. The studies conducted by both Appelt and Koziarz *et al*. [11,12] reported a higher incidence of bleeding, hematoma, false aneurysm, arteriovenous fistula, and other vascular complications associated with brachial artery puncture compared to radial artery puncture. The analysis of the British Society for Cardiovascular Interventional Intervention database [13] reveals that compared to the radial artery approach, the brachial artery approach exhibits a higher incidence of vascular complications, particularly local hematoma. The reasons are as follows: (1) The puncture site is positioned too high. Brachial artery punctures are typically performed at the most prominent brachial artery pulsations, approximately 0.5–1 cm above the cubital crease. This location offers shallow access to the brachial artery, facilitating postoperative pressure bandaging and ensuring ease of hemostasis. Conversely, a higher puncture point would result in deeper penetration into the brachial artery, which is unfavorable for effective pressure hemostasis [14]. (2) Arterial lateral puncture or transmural puncture, both of which can result in challenges with achieving hemostasis and increase the risk of bleeding [15]. (3) During the postoperative period, inadequate immobilization of the elbow joint led to movement of the compression position and subsequent bleeding [16]. (4) The intensity of the postoperative pressure bandage is insufficient to effectively achieve hemostasis. (5) The frequent puncturing can lead to bleeding at the puncture site, formation of local hematoma, and development of false aneurysm [17]. The reasons for the discrepancy in the incidence of local vascular complications following brachial artery puncture between this study and other domestic and international studies are as follows: (1) Brachial artery puncture was performed early and with expertise at our center, with all procedures conducted by a single skilled surgeon. (2) Our center boasts a comprehensive postoperative follow-up medical team that diligently monitors the puncture site throughout the entire process, promptly identifying and resolving any issues.

In this study, one patient (a 48-year-old male) exhibited vagal reflex. According to Vidri *et al*.'s research [18], the factors contributing to vagal reflex include: (1) The likelihood of occurrence is higher among individuals experiencing lower pain threshold or mental stress. (2) Preoperative fasting and water deprivation can lead to increased blood concentration and reduced blood volume, which is more likely to occur. (3) Insufficient local infiltration anesthesia may increase the likelihood of this phenomenon. Analysis of a case of vagal reflex in this study suggests that it may be associated with lower pain threshold and mental stress.

The feature of this study is the continuous extraction of the sheath pipe for 6 hours, which always avoids delving too deeply into the analysis. By comparing the safety and efficacy of PCI via the radial artery and PCI via the brachial artery with immediate sheath removal after the procedure (A group) or 6 hours post-procedure (B group), it is concluded that PCI treatment via brachial artery is not inferior to that via radial artery in elderly patients. The use of brachial artery access in elderly patients does not impact postoperative comfort and has no effect on the total operation time and length of hospital stay. Delaying the removal of the brachial artery sheath by 6 hours after surgery reduces the occurrence of epidermal blisters compared to immediate removal after surgery. The selection of brachial artery puncture as an alternative approach in elderly patients undergoing PCI, when radial artery access is contraindicated, can be considered a relatively safe and effective intervention method that minimizes injury. To address the limitations associated with brachial artery puncture, it is recommended to remove the sheath and apply compression bandage 6 hours after PCI, which enhances safety and effectiveness.

This study is a single center retrospective study. The selected patients in the brachial artery group switched to the brachial artery approach for PCI treatment due to failed bilateral brachial artery puncture or catheterization, resulting in selection bias in the brachial artery group. However, this approach is consistent with clinical practice. Multiple studies have reported the risk of serious vascular complications in the brachial artery approach PCI, and there is a lack of sufficient evidence to support it. Therefore, the radial artery approach is chosen as the preferred clinical practice, which is also the main limitation of this study. In addition, the variables included in this study are all observational indicators, and the statistical analysis is relatively simple. Although known confounding factors have been adjusted for in statistical methods, the reliability of the research results may still be affected by potential uncorrected confounding factors. Therefore, large-scale, multicenter randomized controlled studies are needed in the future to further explore and verify the safety and effectiveness of brachial artery coronary intervention in elderly patients with different extubation times compared to radial artery approach.

Conclusion

In elderly patients, coronary intervention through brachial artery is not inferior to radial artery. The brachial artery approach does not reduce the postoperative comfort of elderly patients, and has no effect on the duration of operation and hospitalization. The brachial artery sheath removal 6 hours after operation is more effective and safer than immediate removal after operation.

Availability of Data and Materials

The data underlying this study are contained within the article.

Author Contributions

LYL, FR, YLX, QRL, QYW, GR, QWL, LW and FG designed the work and extracted the data. LYL, FR, YLX, QRL, and QYW analyzed the data. GR, QWL, LW, and FG wrote the first draft of the manuscript. All authors critically read and approved the final version of the manuscript. All authors contributed to editorial changes in the manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

The Ethics Committee of Beijing Aerospace General Hospital approved the project (2024-clinical-08). All methods were carried out in accordance with relevant guidelines and regulations. All patients signed informed consent forms.

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Conflict of Interest

The authors declare no conflict of interest.

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