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Original Article

Distal transradial access decreases radial artery occlusion rate in percutaneous coronary interventions

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Abstract: Background: To investigate the incidence of complications such as radial artery occlusion (RAO) after distal or conventional transradial access in percutaneous coronary interventions, and to compare the advantages and disadvantages of those two approaches. Methods: In this retrospective study, the data of 110 patients received either distal transradial access (dTRA) (n=56 cases) or conventional transradial access (cTRA) (n=54 cases) in percutaneous coronary interventions were analyzed to compare the incidence of RAO. Results: The incidence of RAO in the dTRA group significantly decreased compared with that in the cTRA group (P<0.05). Univariate analysis indicated that smoking (r=0.064, P=0.011), dTRA (r=0.431, P<0.001), cTRA (r=0.088, P=0.015), radial artery spasm (r=-0.021, P=0.016), and postoperative arterial compression time (r=0.081, P<0.001) were exposure factors for the incidence of RAO. In multivariable analysis, independent risk factors for RAO were postoperative arterial compression time (P=0.038) and dTRA (P<0.001). Conclusions: dTRA shortened the postoperative arterial compression time and decreased the incidence of RAO compared with conventional transradial approach.

Keywords: Radial artery occlusion, percutaneous coronary interventions, distal or conventional transradial access

Introduction

Cardiovascular disease is the leading cause of death and the second largest source of healthcare cost in the world [1]. Acute coronary syndrome (ACS) accounts for 50% of cardiovascular related deaths [2]. As a major public health issue in developing countries, ACS has become highly prevalent. It is responsible for 35% of all deaths across the world with 1 million deaths each year [3]. The main treatment method for ACS is percutaneous coronary intervention (PCI). Forearm artery access has become the main surgical access for coronary intervention [4, 5]. Compared with coronary intervention through the femoral artery, coronary diagnosis, and treatment through the forearm artery significantly reduces bleeding, and improves the prognosis of patients with ST segment elevation acute myocardial infarction [6].

With the popularization of PCI, choosing the appropriate intervention approach has become a primary issue. Radial artery puncture through forearm has become the most common PCI pathway in the clinic [7]. Forearm radial artery has some complications. A vascular ultrasound study showed that the incidence of radial artery occlusion (RAO) after PCI through forearm radial artery puncture was 30% [8]. The distal radial artery approach has become a new way of intervention. The distal radial artery approach is a triangular depression formed by the tendons of abductor pollicis longus and extensor pollicis brevis, extensor pollicis longus, and styloid process of radius. Some studies have shown that PCI through the distal radial artery approach can shorten the time for postoperative compression and hemostasis. It can reduce the incidence of postoperative complications, making up for some shortcomings of the traditional forearm radial artery intervention approach [9-12].

PCI through radial artery has many advantages. Radial artery access has been shown to cause fewer complications at the vascular access site, allow earlier ambulation, offer greater postprocedural comfort for the patient, and be cost-effective. In patients with acute coronary syndrome, it reduces net adverse clinical events, through a reduction in major bleeding and all-cause mortality [13-15]. Vascular complications are common, which included radial artery spasm, radial artery occlusion (RAO), hematoma, false aneurysm, arteriovenous fistula, and compartment syndrome [16]. RAO is one of the most common vascular complications related to the PCI [17, 18]. Few clinical studies have assessed the incidence of RAO after distal transradial access (dTRA) or conventional transradial access (cTRA) in PCI.

The aim of the present study was to investigate the incidence RAO after dTRA or cTRA in PCI, and to compare the advantages and disadvantages of those two approaches.

Materials and methods

Study design

In this retrospective study, data of 110 patients received PCI from January 2020 to March 2022 in The First People's Hospital of Guiyang were collected. The patients received either dTRA (n=56 cases) or cTRA (n=54 cases). The research was conducted with the approval of Ethics Committee of The First People's Hospital of Guiyang.

Inclusion and exclusion standard

Inclusionve criteria: ① Patients who were diagnosed with ACS and received PCI for the first time [19]; ② Patients with a positive Allen test and normal pulsation at radial artery or the distal end of the radial artery; ③ Patients who were over 18 years old; ④ Patients received Doppler ultrasound examination of the radial artery on the operation side about one week after the operation.

Exclusion criteria: ① Patients with a negative Allen test or untouched radial artery; ② Patients with a history of PCI via through dTRA or cTRA; ③ Patients with hypotension; ④ Patients with a history of malignant tumor; ⑤ Patients who were pregnant or in lactation; ⑥ Patients with acute myocardial infarction within one week; ⑦ Patients with incomplete clinical data.

Interventions

The dTRA group: The patients were placed in a horizontal position, with the right arm naturally placed on the side of the body, and the back of the palm outward. After local anesthesia through lidocaine (Wuhan Demikai Biotechnology Co., Ltd.), the Seldinger technique was used to puncture the strongest point of the radial artery in the Hegu Point area. After the successful puncture with pulsatile blood return, the guide wire was placed into the sheath of 5F or 6F radial artery (Radifocus® Introducer II, Talmao Co., Ltd., Tokyo, Japan). A total of 200 μg nitroglycerin (Shanghai Xinyi Pharmaceutical Co., Ltd.) and 2000 u heparin (Shanghai Xinyi Pharmaceutical Co., Ltd.) were administered in the sheath. Under the guidance of 0.035 in contrast guide wire (Talmao Co., Ltd., Tokyo, Japan), multi-functional contrast catheters (TIG/jr3.5/4.0, jl3.5/4.0) (Radifocus® Introducer II, Talmao Co., Ltd., Tokyo, Japan) were used to complete the operation. An elastic bandage (Shanghai Kangdelai Medical Equipment Co., Ltd.) was used to compress and stop the bleeding the after operation (**Figure 1D-F**).

The cTRA group: The patients were in a horizontal position, the right arm was extended, and abducted. The palm was upward and the right arm was fixed. After local anesthesia through lidocaine (Wuhan Demikai Biotechnology Co., Ltd.), the Seldinger technique was used to puncture the pulsation point of the radial artery 2-3 cm from the proximal end of the styloid process of the radius. The guide wire (Radifocus® Introducer II, Talmao Co., Ltd., Tokyo, Japan) was routinely inserted into the radial artery sheath. Nitroglycerin (Shanghai Xinyi Pharmaceutical Co., Ltd.) and heparin (Shanghai Xinyi Pharmaceutical Co., Ltd.) were administered in the sheath. Coronary angiography was the same as that of the dTRA group. An elastic bandage (Shanghai Kangdelai Medical Equipment Co., Ltd.) was used to compress and stop the bleeding after the operation (**Figure 1A-C**).

Observation indexes

Primary outcome measures: ① Puncture condition: The average puncture times and puncture time were recorded. ② Postoperative complications: Local hematoma, radial artery spasm, arteriovenous fistula, pseudoaneurysm, and forearm RAO were recorded.

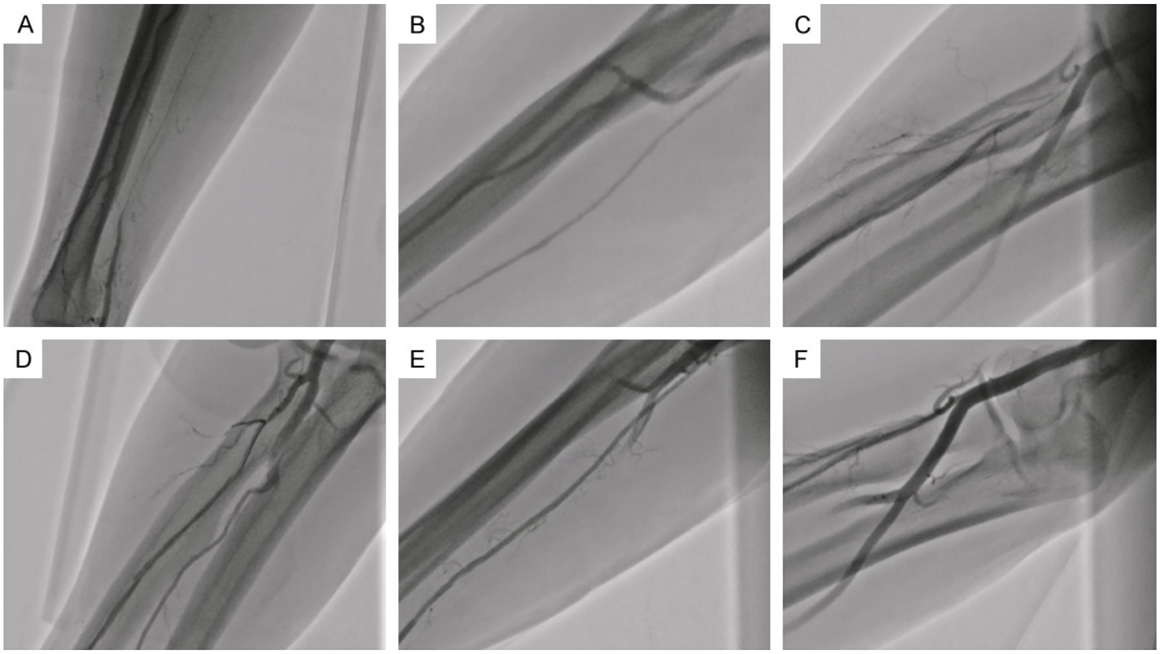

Figure 1. The angiography image of the two approaches. A-C: Percutaneous coronary interventional through conventional transradial access; D-F: Percutaneous coronary interventional through distal transradial access.

Secondary outcome measures: ① Operation related indicators: The X-ray exposure time, the amount of contrast medium used, the number of catheters used, the operation time, the time of postoperative arterial compression, the hospital stay, and the success rate of coronary angiography were recorded. ② Postoperative pain: The visual analog scale (VAS) was used to evaluate the pain of the two groups at 3 h, 6 h, and 12 h after the operation. The score range was 0-10, and the score increased with the increase of pain. ③ Basic clinical data of the subjects: We collected the basic clinical data of all subjects. The data included age, body mass index (BMI), smoking, blood fat, hypertension, diabetes, cerebral infarction, length of hospital stay, and left ventricle ejection fraction. The blood lipid level was detected by collecting 3-5 ml of morning fasting venous blood. The Beckman Coulter AU5800 automatic biochemical analyzer was used to detect total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), very low-density lipoprotein cholesterol (VLDL-C), apolipoprotein A (Apo A), and apolipoprotein B (Apo B). The normal reference ranges of blood lipids are as follows: TC (2.8-5.7 mmol/L), TG (0.3-1.7 mmol/L), HDL-C (1.2-2.0 mmol/L), LDL-C (2.0-4.0 mmol/L), VLDL-C (0.03-0.4 mmol/L), Apo A (1-1.8 mmol/L), and Apo B (0.6-1.1 mmol/L). All subjects received a color Doppler ultrasound to measure left ventricular ejection fraction.

Statistical analysis

All the data in this study were processed by SPSS19.0. The measured data were expressed as mean ± SD. The comparison between the two groups before and after the intervention were conducted through the paired t test. Factors that were significant at the $P<0.05$ level in the univariate analysis were subjected to multivariate analysis. The multiple regression analysis (stepwise method) was used to identify the risk factors for RAO. In all analyses, P value <0.05 stands for a significant difference.

Results

Clinical data

The two groups were similar regarding age, sex, BMI, smoking, hypertension, dyslipidemia, diabetes, cerebral infarction, and left ventricular ejection fraction (**Table 1**). There were no significances between the two groups before the intervention ($P>0.05$).

Table 1. Comparison of clinical data between the two groups

	dTRA group (n=56)	cTRA group (n=54)	t/χ^2	*P*
Age (years)	54.1±6.9	51.4±7.1	3.252	0.241
Sex			3.281	0.422
Male (n%)	38 (67.9%)	36 (66.7%)		
Female (n%)	18 (32.1%)	18 (33.3%)		
BMI	22.7±2.28	21.4±2.76	1.209	0 .333
Smoking	37 (66.1%)	39 (72.2%)	1.962	0.592
Dyslipidemia	18 (32.1%)	22 (40.7%)	17.831	0.243
hypertension	23 (41.1%)	19 (35.2%)	9.978	0.213
Diabetes	20 (35.7%)	22 (40.7%)	9.954	0.062
Cerebral infarction	12 (21.4%)	13 (24.1%)	6.783	0.076
Left ventricular ejection fraction	0.56±0.08	0.62±0.06	5.762	0.074

Note: BMI: body mass index; cTRA: conventional transradial access; dTRA: distal transradial access.

Table 2. Comparison of operation related indicators between the two groups

group	dTRA group	cTRA group	t	p
Number of cases	56	54	-	-
Completion time of angiography (min)	12.2±2.4	11.9±2.3	4.578	0.095
Contrast agent usage (ml)	56.28±14.76	61.28±8.74	2.165	0.584
Number of catheters used	2.24±0.89	2.18±1.11	1.675	0.567
Postoperative arterial compression time (min)	2.64±1.13	3.98±1.09	3.973	0.032
length of stay	6.785±2.87	7.362±2.73	2.198	0.463

Note: cTRA: conventional transradial access; dTRA: distal transradial access.

Table 3. Comparison of puncture condition between the two groups

group	Number of cases	Average puncture times (times)	Average puncture time (min)
dTRA group	56	1.2±0.4	5.28±1.76
cTRA group	54	1.9±0.3	4.28±1.74
t	-	4.778	7.165
P	-	0.065	0.024

Note: cTRA: conventional transradial access; dTRA: distal transradial access.

Comparison of operation related indicators between two groups

As shown in **Table 2**, completion time of angiography, contrast agent usage, number of catheters used, and length of stay had no significant difference between the two groups. The postoperative arterial compression in the dTRA group was significantly shorter than that in the cTRA group (P<0.05).

Comparison of puncture condition between the two groups

All patients were punctured successfully. The average puncture time in the dTRA group was longer than that in the cTRA group (P<0.05). There was no significant difference in the average puncture times between the two groups (P>0.05) (**Table 3**).

Comparison of adverse reactions between the two groups

As shown in the **Table 4**, the incidence rate of RAO in the dTRA group was 1.7%. It was 13% in the cTRA group, with a significant difference between the two groups (P<0.05). The total complication rate in the dTRA group was lower than that in the cTRA group (P<0.05). This indicated that PCI through dTRA can decrease the incidence of adverse reactions, especially the RAO.

Table 4. Comparison of adverse reactions between the two groups

	dTRA group (n=56)	cTRA group (n=54)	t	*P*
Local hematoma	11 (1.7%)	88 (14.8%)		
Radial artery spasm	3 (5.3%)	8 (14.8%)		
Arteriovenous fistula	0 (0)	0 (0)		
Pseudoaneurysm	0 (0)	2 (3.7%)		
Radial artery occlusion	1 (1.7%)	7 (13%)		
Total incidence	5 (8.7%)	25 (46.3%)	7.593	0.032

Note: cTRA: conventional transradial access; dTRA: distal transradial access.

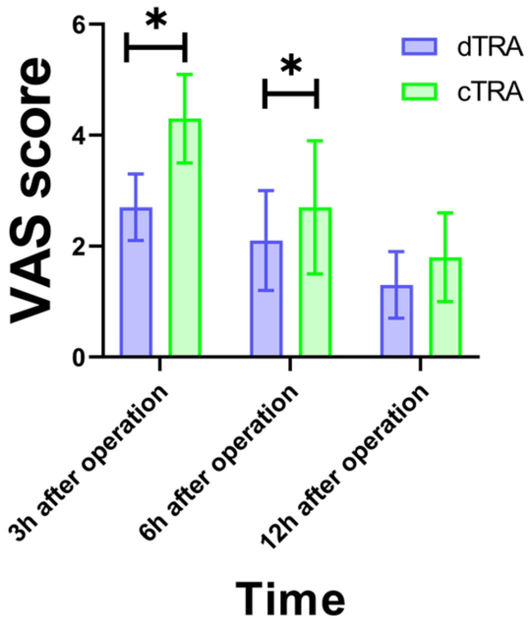

Figure 2. Comparison of visual analogue scale which introduced cTRA group and dTRA group.

Comparison of postoperative pain between the two groups

The VAS score of the dTRA group was lower than that of the cTRA group at 3 h and 6 h after operation (P<0.05). There was no significance between the two groups at 12 h after the operation (P>0.05) (**Figure 2**).

Univariate and multivariate logistic regression analysis

We assessed the risk factors for RAO in the patients. The data included age ≥30 (years), BMI ≥19 kg/m^2, smoking, dyslipidemia, hypertension, diabetes, cerebral infarction, dTRA, length of hospital stay, ejection fraction, cTRA, local hematoma, radial artery spasm, arteriovenous fistula, pseudoaneurysm, completion time of angiography, contrast agent usage, number of catheters used, postoperative arterial compression time, average puncture times, average puncture time, and VAS score. The univariate and multivariate logistic regression analysis were performed. The univariate analysis showed that smoking, dTRA, cTRA, radial artery spasm, and postoperative arterial compression time were related to the incidence of RAO, as shown in **Table 5**. The multivariate logistic regression analysis demonstrated that postoperative arterial compression time (P=0.038) and dTRA (P<0.001) were independent risk factors for RAO, as shown in **Table 6**.

Discussion

With the gradual development and maturity of radial artery interventional diagnosis and treatment technology [20, 21], PCI has become the class I recommendation [22, 23]. The characteristics of the radial artery include a small diameter, tortuous, radial artery ring, and an easy occurrence of vasospasm. PCI through radial artery has congenital defects or limitations. RAO is one of the most important and common postoperative complications. In our study, the incidence of RAO in the dTRA group was 1.7%. This was lower than that in the cTRA group (13%), indicating that dTRA can significantly decrease the incidence of RAO. The main mechanism of RAO is the damage of blood vessel wall caused by catheterization and the reduction of blood flow speed caused by postoperative compression hemostasis, resulting in red thrombosis [24-26]. When the radial artery of the forearm enters the snuff pot area, it bifurcates into the distal radial artery and the superficial palmar branch. After the dTRA puncture site is bifurcated, the blood flow of the radial artery of the forearm can be circulated through the superficial palmar arch formed by

Table 5. Univariate logistic regression analysis

Indexes	β	SE	OR (95% CI)		*P*
Age ≥30 (years)	-0.071	0.993	0.911	1.083	0.454
BMI ≥19 (kg/m^2)	-0.070	1.018	0.999	1.037	0.461
SmokingSmoking	0.064	1.051	1.018	1.085	0.011
Dyslipidemia Dyslipidemia	-0.032	0.953	0.488	1.860	0.743
hypertension	0.367	2.594	1.255	5.358	0.064
Diabetes	0.338	2.293	0.728	7.227	0.084
Cerebral infarction	0.458	0.949	0.103	8.705	0.661
dTRA	0.431	3.93	0.538	28.704	<0.001
Length of hospital stay (days)	0.276	1.772	0.855	3.671	0.054
Left ventricle ejection fraction	0.174	1.018	0.484	2.141	0.064
cTRA	0.088	1.007	0.996	1.108	0.015
Local hematoma	-0.070	0.989	0.985	0.993	0.461
Radial artery spasmRadial artery spasm	-0.021	1.188	1.016	1.388	0.016
Arteriovenous fistula	-0.032	0.993	0.986	0.999	0.093
Pseudoaneurysm	0.367	1.134	1.034	1.244	0.074
Completion time of angiography	0.338	1.000	1.000	1.001	0.064
Contrast agent usage	0.548	0.916	0.820	1.023	0.054
Number of catheters used	0.675	1.158	1.069	1.255	0.076
Postoperative arterial compression time	0.087	1.133	1.060	1.212	<0.001
Average puncture times	0.234	0.982	0.944	1.021	0.051
Average puncture time	0.455	1.008	0.929	1.094	0.054
VAS score	0.046	1.013	0.948	1.084	0.529

Note: BMI: body mass index; cTRA: conventional transradial access; dTRA: distal transradial access; VAS: visual analogue scale.

Table 6. Multiple regression analysis

Dependent variables	Independent variables	B	SE	β	*P*
Radial artery occlusion	Postoperative arterial compression time	0.203	0.053	0.333	0.038
	dTRA	1.288	0.394	0.284	<0.001
	Smoking	0.032	0.011	0.187	0.132
	cTRA	1.285	0.482	0.237	0.119
	Radial artery spasm	0.642	0.288	0.199	0.228

Note: B: nonstandard regression coefficient; SE: standard error; b: standardized regression coefficient; β: multiple correlation coefficient adjusted for the degrees of freedom. cTRA: conventional transradial access; dTRA: distal transradial access.

the superficial palmar branch to prevent blood stasis and reduce the occurrence of RAO.

This study found that in the dTRA group the postoperative arterial compression time was significantly shorter than that in the cTRA group. The VAS scores at 3 h and 6 h after the operation were significantly lower than that in the cTRA group. This suggested that coronary angiography through dTRA can shorten the postoperative arterial compression time and provide patients with better comfort. The surface of the distal radial artery is shallow. There are many bony structures around it, making it easier to compress and stop bleeding. The diameter and pressure of the distal radial artery are slightly shorter/lower than that of the proximal end. The compression hemostasis effect is better, and the hemostasis time can be shortened [27, 28]. Compared with receiving cTRA, patients do not need to keep their forearms straight and palms upward during dTRA puncture. The comfort of hand placement during the operation is high, and the wrist does not need to be braked after the operation. The movement is not limited. This helps to avoid bleeding, swelling and pain, and improves the comfort of patients [29].

Reducing the risk of postoperative complications after coronary angiography is the focus of clinical attention. This study found that the total incidence of postoperative complications in the dTRA group was significantly lower than that in the cTRA group. This suggested that dTRA coronary angiography can significantly reduce the incidence of postoperative complications. Possible reasons: ① The presence of the superficial palmar arch makes the forward blood flow of the radial artery not be affected by the slow down or occlusion of the distal radial artery. It reduces the injury of the radial artery. The incidence of RAO and arteriovenous fistula is lower [30]. ② The shorter arterial compression time after dTRA does not cause venous obstruction and is able to the occurrence of local hematoma [31].

Limitations of our study should be considered. The sample size of this study was small. Only eight patients were found to have RAO, which affected the persuasion of the observed occlusion rate. This study was a retrospective study with low test efficiency. The occlusion within 1 month after the operation was not statistically analyzed, and there was no control. Due to the limitation of conditions, optical coherence tomography (OCT) could not be performed to observe the arterial intima. A larger-sized randomized controlled study is needed in the next stage.

PCI through dTRA can shorten the time of arterial compression after the operation, provide good comfort to patients, and lead to fewer complications. It can be used as an alternative puncture route for clinical coronary angiography.

Disclosure of conflict of interest

None.

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