

Original Article

Success rate, efficacy and complications of the transradial artery approach to percutaneous coronary intervention for coronary heart disease

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Abstract: Background: Percutaneous coronary intervention (PCI) is effective in treatment of coronary atherosclerosis. Conventionally, PCI is extensively performed via femoral artery access; however, the technique is associated with a range of disadvantages including more vascular complications and prolonged bed rest. The transradial artery approach (TRA) to PCI is an interventional procedure which has proven to be safer and more effective, with fewer complications. It has been widely used in clinical practice in recent years. Objective: To observe and compare the success rate, efficacy and complications of transradial versus transfemoralartery approaches to percutaneous coronary interventions (PCI) in patients with coronary heart disease (CHD), building up a good basis for clinical practice. Methods: In the present study, a total of 150 patients admitted to our hospital from June 2012 to June 2016 were randomly assigned to receive the PCI via transradial artery (TRA) access (the radial artery group, n=72) or the PCI via transfemoral artery (TFA) access (the femoral artery group, n=78). The two groups were compared in preoperative prothrombin time and platelet counts, successful cases of arterial punctures, PCI procedure time, fluoroscopy time, success rate of PCI, time for arterial sheath insertion, haemostatic time, as well as postoperative local and systemic complications. Results: There was no significant difference in such risk factors as prothrombin time and platelet counts between the two groups ($P>0.05$). The radial artery group had significantly longer PCI procedure time, time for arterial sheath insertion, but shorter hemostatic time than the femoral artery group ($P<0.05$). The patients in the two groups showed no significant differences in fluoroscopy time, success rates of arterial puncture and PCI ($P>0.05$). The radial artery group had significantly fewer cases of postoperative arterial spasms, arterio-venous fistula and of puncture site-related hemorrhage, as well as a lower incidence of vagus nerve compression and reflex than the femoral artery group ($P<0.05$). There was also no significant difference in other vascular complications. Conclusion: In the clinically interventional procedures in patients with CHD, the PCI via transradial artery access can bring less vascular complications, shortened hemostatic time, reduced puncture site-related postoperative hemorrhage, as well as greatly improved therapeutic efficacy and safety although it cannot improve the success rate of the surgery.

Keywords: Coronary heart disease, transradialartery approach to percutaneous coronary intervention, femoral artery, efficacy, complication

Introduction

Coronary heart disease (CHD) is known as “the number one killer of human health”, and the incidence of the disease is rising in the trend of growing younger patients [1]. Abnormal lipid metabolism contributes to lipid accumulation in the blood in the arterial intima, and ultimately to lipid plaque and secondary atherosclerosis, which leads to stenosis of coronary artery lumens, poor blood flow, and occlusion in the “nutrition supply line” of the heart. All this results in the development of angina, myocar-

dial infarction, or even threats to the patients' lives, severely affecting the patients' survival and quality of life [2, 3]. There are currently three major categories of protocols for treatment of CHD: medication alone, coronary artery bypass graft (CABG), and percutaneous coronary intervention (PCI) [4-6]. Among them, PCI comprises percutaneous transluminal coronary angioplasty (PTCA), coronary stent and other techniques [4, 7]. Coronary intervention mainly adopts two modalities: transfemoral artery intervention (TFA) and transradial artery intervention (TRA). After more than two decades of clini-

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cal practice, the safety and feasibility of TRA to PCI in treatment of CHD has been recognized by the majority of intervention physicians and it has proven to be effective [8]. Due to the superficial location of the radial artery, the artery is easy to compress, with less puncture site-related complications. What's more, since no important blood vessels and nerves are near the radial artery, radial artery punctures cause less damage to nerves and blood vessels. The patients are not required long postoperative bed rest, significantly increasing the comfort of patients [9]. Despite the above mentioned benefits of TRA, compared with TFA, smaller diameter of the radial artery, fewer successful punctures, and significantly more puncture site-related vascular complications are also observed in TRA for PCI [10]. However, the merits and demerits of the two intervention approaches are unclear. Therefore, the present study was to analyze and compare the variables related to success rate, efficacy and complications of the two approaches to intervention treatment of CHD, with the aim to provide guidance for effective interventions in treatment of CHD, reducing adverse events affecting radial artery structure as well as complications in the process of PCI.

Materials and methods

Demographic data

The present study was approved by the Clinical Ethics Committee and all the patients signed informed written consents approved by the ethics committee. The patients who were admitted to our hospital and diagnosed as having atherosclerotic coronary heart disease from June 2012 to June 2016 were eligible for this study. The patients who were accompanied by other organ-severely damaged diseases and contraindications to PCI were excluded. A total of 150 patients were enrolled as subjects and randomly assigned to receive the transradial artery approach (TRA) to PCI (the radial artery group, n=72) or the transfemoral artery approach (TFA) to PCI (the femoral artery group, n=78).

Methods

Surgical procedures: The femoral artery group: The site at the femoral artery with the strongest pulse below the right inguinal ligament or 0.5-1 cm below the femoral artery of the patient was taken as the puncture access. Under lo-

cal anesthesia with 0.5 ml of 1% lidocaine, an 18-gauge puncture needle was inserted into the right femoral artery. Of note, the needle was advanced in the same direction as the femoral artery did. After the successful puncture, a sheath was placed into the femoral artery. Slow bolus of nitroglycerin was administered into the sheath canal, followed by intravenous heparin injection. It is noted to record the insertion time and then perform the coronary angiography [11].

The radial artery group: Firstly, the Allen test was used to assess anastomosis between radial and ulnar arteries of the patient: the patient was requested to lift the right arm to the same level of the heart and clench the right fist tightly. An examiner simultaneously pressed both hands on the radial and the ulnar arteries of the patients for 5 seconds, and then the patient was instructed to repeatedly clench the right fist tightly and open the fingers for 5-7 times until the palm turned pale. Ulnar pressure was released while radial pressure was maintained, and then the examiner observed the color changes of the palm. If the color of the palms rapidly becomes red or the normal color within 10 s, suggesting there is a good collateral circulation between the ulnar and radial arteries, i.e. the result of the Allen's test is negative. This indicates it is safe for the TRA to PCI and no ischemia would occur even in the case of radial artery occlusion. Conversely, if the color of the palm fails to get normal, then the result of the test is positive. This suggested that the collateral circulation of the palm was poor and it may not be suitable for the TRA for PCI. The site at the radial artery with the strongest pulse, 1-2 cm above the cross striation of the patient's right palm was taken as the puncture access. Under local anesthesia with 0.5 ml of 1% lidocaine, an 18-gauge puncture needle was inserted into the right radial artery went. It is noted that the needle was advanced in the same direction as the radial artery. After the successful puncture, a sheath was placed into the radial artery. Slow bolus of nitroglycerin was administered into the sheath canal to prevent arterial spasm. Heparin was intravenously injected and then the coronary angiography was performed. It is noted to record the insertion time [11, 12].

After completion of either of the above two approaches to PCI, coronary angiography was

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Table 1. Demographics and risk factors of the two groups

Variables	Radial (n=72)	Formal (n=78)	P
Male/Female	40/32	45/33	0.792
Age (year)	67.2±3.4	66.2±2.5	0.1942
Hypertension (n)	38	42	0.896
Diabetes mellitus (n)	12	15	0.683
Triglycerides (mmol/L)	1.5±0.08	1.7±0.12	0.0906
Prothrombin time (s)	12.3±5.2	15.8±3.3	0.0617
Platelet (10 ¹² /L)	245±45	270±30	0.1558

performed, first the left then the right coronary angiography, to identify the sites and types of lesions in the coronary artery.

Outcome measures: The primary outcomes were PCI procedure time, hemostatic time, success rate of PCI, arterial spasms, cases of arteriovenous fistula, puncture site-related hemorrhage and vagus nerve compression and reflex.

The secondary outcomes included fluoroscopy time, hematoma, artery occlusion, pseudoaneurysm, mediastinal and pleural hematoma.

Statistical analysis

Statistical analysis was performed using SPSS software, version 17.0. All the categorical data were expressed as percentages, and compared by the chi square test. All the quantitative data were expressed as mean ± SD and the intergroup differences were compared using the t test. P<0.05 was considered to be statistically significant.

Results

Demographic data and risk factors of the two groups

No significant differences in demographic data including gender and age were found between the two groups (P>0.05). There were no significant differences in diabetes, hypertension, or hyperlipemia between the two groups (P>0.05). The two groups did not differ significantly in preoperative prothrombin time and platelet counts (P>0.05, **Table 1**).

PCI variables of the two groups

The radial artery group had significantly longer PCI procedure time, time for arterial sheath insertion (P<0.05), but shorter hemostatic time than the femoral artery group (P<0.05).

The patients in the two groups showed no significant differences in fluoroscopy time, success rates of arterial puncture and PCI (P>0.05, **Table 2**).

Postoperative complications in the two groups

The radial artery group had significantly less cases of postoperative arterial spasms, arteriovenous fistula and of puncture site-related hemorrhage, as well as lower rates of vagus nerve compression and reflex than the femoral artery group (P<0.05).

There was no significant difference in the proportions of cases of postoperative hematoma and arterial occlusion, pseudoaneurysm, mediastinal and pleural hematoma between the two groups (P>0.05, **Table 3**).

Discussion

In the interventional treatment of CHD, the TFA was the first technique and had been still used [13]. Although the TFA is easy to operate as the inner diameter of the femoral artery is large, due to the special anatomical site of the femoral artery (it communicates with femoral veins and femoral nerves), the surgery is associated with vulnerable femoral nerves and an array of complications including retroperitoneal hematoma [14]. Since Campeau, a Canadian physician, firstly succeeded in conducting the transradial artery puncture for coronary angiography in 1989, and Ferdinand Kiemeneij, a Holland physician, reported his successful TRA for PCI in treatment of CHD, the TRA technique has developed rapidly and its benefits have got increasing recognition [15, 16]. Because of the superficial position of the radial artery, it does not accompany the radial nerves and the radial veins. As a result, the damages to the nerves and veins are smaller in the course of puncture and operation [17]. Besides, the palm has a dual blood supply, in which the ulnar artery also plays an important role in addition to the radial artery. Once the radial artery is occluded during puncture or surgery, the blood is supplied by

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Table 2. Clinical data of the two groups

Variables	Radial (n=72)	Formal (n=78)	P
Successful puncture (n)	72 (100%)	74 (94.9%)	0.051
PCI procedures (min)	48.7±26.2	53.3±24.8	0.0295*
Fluoroscopy (min)	13.9±6.8	15.6±5.2	0.8290
Successful PCI (n)	70 (97.2%)	68 (87.2%)	0.024*
ASI (min)	1.3±0.5	2.5±0.6	0.0023*
Haemostasis (min)	20.4±2.5	1.5±0.5	0.0037*

Note: *P<0.05 is considered to be significantly different. PCI denotes percutaneous coronary intervention, and ASI denotes Arterial sheath insertion.

Table 3. Postoperative complications in the two groups

Variable	Radial (n=72, %)	Formal (n=78, %)	P
Arterial spasm	10 (13.9)	2 (2.6)	0.011*
Arteriovenous fistula (n)	6 (8.3)	0 (0)	0.009*
PSRH (n)	11 (15.28)	2 (2.56)	0.006*
Haematoma (n)	5 (6.94)	0 (0)	0.018*
Artery occlusion (n)	5 (6.94)	0 (0)	0.018*
Pseudoaneurysm (n)	2 (2.78)	1 (1.28)	0.513
VNCR (n)	6 (8.33)	0 (0)	0.009*
MPH (n)	0 (0)	1 (1.28)	0.335

Note: *P<0.05 is considered to be significantly different. PSRH denotes puncture site-related hemorrhage; VNCR vagusnerve compression and reflex; MPH mediastinal and pleural hematoma.

the ulnar artery. The present study indicated that there were significantly fewer cases of puncture site-related postoperative hemorrhage in the radial artery group than in the femoral artery group after PCI. However, no significant differences were found in cases of other vascular complications including arterial spasm, arteriovenous fistula, hematoma, pseudoaneurysm, arterial occlusion, which might be attributed to the fact that after the successful puncture of the artery catheter, slow bolus of nitroglycerin was administered into the sheath canal to prevent arterial spasms or occlusion. After the removal of the sheath, the puncture site was pressed, so the incidence of hematoma significantly reduced in both study groups. Jolly et al. found similar results to ours that the incidence of local vascular complications after the TRA to PCI was lower than that of the TFA to PCI [18].

In our study, fewer subtypes and a significantly lower incidence of postoperative complications

were observed in the radial artery group than in the femoral artery group. Two cases of arterial spasm, two cases of puncture site-related postoperative hemorrhage, one case of pseudoaneurysm, one case of mediastinal and pleural hematoma occurred in the radial artery group. There are a large number of elastic fibers in the radial walls, the internal diameter of the artery is fine, and the vascular walls are mainly distributed with α 1-adrenergic receptors. Consequently, the radial artery was extremely sensitive to the circulating catecholamines. The levels of catecholamine in the blood circulation increase with the excitation of sympathetic nerves, which directly stimulates the blood vessels, leading to the presence of spasms in the radial artery [19, 20]. In addition, the increase in catecholamine levels resulting from the patient's preoperative tension, anxiety and pain, along with other factors also contributes to the presence of spasms in the radial artery. In such cases, the patients should immediately be given sufficient sedatives or preoperative vasodilators [21, 22]. Pseudoaneurysm is caused by a penetrating injury to the vessel, which then bleeds. The blood infiltrates into the surrounding soft tissues and forms localized pulsatile mass in the surrounding soft tissues. In our study, the occurrence of pseudoaneurysm may be due to the injured artery during the vascular intervention procedures. Once pseudoaneurysm occurs, it can be treated by ultrasound-guided compression or ultrasound-guided thrombin injection [23, 24]. The greatest advantage of TRA for PCI is that it can reduce the incidence of puncture site-related hemorrhage. Once such hemorrhage occurs, the radial pressure below the puncture access is conducive to local hemostasis. It is noted that as the radial artery communicates with the femoral artery, hemostasis by compressing the puncture site should be done by compressing simultaneously both the near and distal ends of the puncture site to prevent puncture site-related hemorrhage or hematoma as a result of the blood supply to the ulnar artery. The patients with mediastinal or pleural hematoma are present with hypotensive shock including chest pain,

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shortness of breath, vomiting, fine pulse, pallor, which might be the reasons that the blood vessels are punctured during the coronary arterial catheterization. In such cases, rapid volume expansion should be performed to correct the shock. The etiology should be ascertained after the patient's vital signs are stable [25].

Our study found that the radial artery group had significantly longer PCI procedure time, time for arterial sheath insertion, but shorter hemostatic time than the femoral artery group ($P < 0.05$). This might be associated with the surgeon's familiarity with the intervention approaches. In addition, the diameter of the radial artery is small, so the radial artery is not easy to puncture, leading to significantly longer time for arterial sheath insertion in the radial artery group than in the femoral artery group. Chen et al. also reported that the time for PCI procedure and catheterization was significantly longer with the TRA than with the TFA for PCI [26]. It is believed that with the increasing skilled catheterization of the clinician, the above differences will be reduced gradually.

In our study, the patients in the radial artery group converted to femoral artery puncture for PCI after they had failed in radial artery puncture, which might be related to the small inner diameter of the radial artery, or local hematoma and arteriovenous fistula caused by the disrupted vessel during the procedure. It also reminds us that the femoral artery puncture can be used as an alternative protocol. Jang et al. also reported in the radial artery group, four patients who had failed in radial artery puncture underwent PCI after they converted to femoral artery puncture [27].

The limitations of our study include the small sample size and short follow-ups. The possibility could not be ruled out that significant difference in the clinical efficacy may exist between the two groups given a large sample size and long-term follow-ups. In addition, our study is not randomized, double-blind in nature, which might cause a great selection bias, affecting the reliability of the results.

Conclusion

In the clinically intervention procedures in patients with CHD, the transradial artery approach to PCI can bring less vascular compli-

cations, shortened hemostatic time, reduced puncture site-related postoperative hemorrhage, as well as greatly improved therapeutic efficacy and safety although it cannot improve the success rate of the surgery. Thus, it is worth extensively clinical practice.

Disclosure of conflict of interest

None.

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