Feasibility, Safety, and Timing of Repeat Percutaneous Coronary Intervention via Distal Radial Artery Access: A Postprint Study

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Abstract

Background: Percutaneous coronary intervention (PCI) via distal transradial artery access (dTRA) can effectively reduce the incidence of radial artery occlusion, but currently there are no domestic research reports on the feasibility, safety, and timing of secondary PCI via dTRA. Objective: To investigate the feasibility, safety, and timing of secondary PCI via dTRA. Methods: A total of 70 patients admitted to Fuwai Hospital, Chinese Academy of Medical Sciences between July 2021 and July 2022, who were scheduled for secondary PCI via dTRA, were consecutively enrolled. They were divided into a $ $30d group (n=33) and a >30d group (n=37) based on the time interval since the previous PCI via dTRA. General clinical data, procedure-related indicators, coronary artery lesion characteristics, and radial artery diameter at 5 cm, 10 cm, and 15 cm proximal to the radial styloid process before surgery and at 24 hours postoperatively were compared between the two groups. Results: Among the 70 patients, dTRA puncture and catheterization were successful in 69 cases, with a success rate of 98.6% (69/70); among the 67 patients evaluated as requiring secondary PCI, 66 successfully completed secondary PCI, with a success rate of 98.5% (66/67). Comparisons between the two groups showed statistically significant differences in age, platelet count, and the incidence rates of diabetes, left main coronary artery disease, and chronic total occlusion (P<0.05). All patients in both groups had compression dressings removed at 3 hours postoperatively, radial artery pulsation on the puncture side could be palpated immediately after surgery and at 24 hours postoperatively, no cases of radial artery occlusion occurred, and the radial artery patency rate was 100.0% (69/69). Inter-group comparison results showed that the radial artery diameter at 5 cm, 10 cm, and 15 cm proximal to the radial styloid process before surgery and at 24 hours postoperatively was larger in the $ $30d group than in the >30d group (P<0.05); intra-group comparison results showed that the radial artery diameter at 15 cm

proximal to the radial styloid process at 24 hours postoperatively was smaller than before surgery in the $ $30d group, while the radial artery diameter at 5 cm proximal to the radial styloid process at 24 hours postoperatively was larger than before surgery in the >30d group (P<0.05). Conclusion: Secondary PCI via dTRA is safe and feasible, and regardless of whether the time interval since the first PCI via dTRA is $ $30d or >30d, the vascular conditions for secondary PCI via dTRA can be met; clinically, the timing of secondary PCI via dTRA can be determined based on the patient's condition and puncture site.

Full Text

Preamble

Expert Introduction: Gao Lijian is a Chief Physician at the Coronary Heart Disease Center, Department of Cardiology, Fuwai Hospital, Chinese Academy of Medical Sciences. He specializes in interventional treatment of complex coronary lesions and has completed over 1,900 cases of percutaneous coronary intervention (PCI) via distal transradial artery approach (dTRA), including more than 150 chronic total occlusion (CTO) cases annually. He studied abroad at Hermann Memorial Hospital, Texas Medical Center from 2017-2018. Dr. Gao serves on multiple professional committees, including the Chinese Medical Doctor Association Cardiovascular Physicians Branch (Interventional Group), National PCI Training Base Mentor, and is Secretary of the China dTRA Intervention Therapy Club. He has published over 80 clinical research papers, including 8 SCI-indexed papers with 5 focusing on dTRA intervention, and leads one randomized controlled trial on dTRA intervention. He holds 3 national invention patents and 1 new technology patent, has contributed to 11 monographs, participated in 3 National Natural Science Foundation projects, 3 provincial-level projects, and 15 clinical trials. He has been honored as an Outstanding Aid-Xinjiang Cadre, Outstanding Party Member of the National Health Commission, and his team received the "Excellent dTRA Intervention Team" award.

Feasibility, Safety and Timing of Secondary Percutaneous Coronary Intervention via Distal Transradial Artery Approach

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Abstract

Background: Percutaneous coronary intervention (PCI) via distal transradial artery approach (dTRA) effectively reduces radial artery occlusion rates, yet no domestic studies have reported on the feasibility, safety, and timing of secondary PCI via dTRA.

Objective: To investigate the feasibility, safety, and optimal timing of secondary PCI via dTRA.

Methods: We consecutively enrolled 70 patients scheduled for secondary PCI via dTRA at Fuwai Hospital, Chinese Academy of Medical Sciences between July 2021 and July 2022. Patients were divided into two groups based on the interval since their last dTRA PCI: the $ $30 days group (n=33) and the >30 days group (n=37). We compared general clinical characteristics, procedure-related metrics, coronary lesion profiles, and radial artery inner diameters at 5 cm, 10 cm, and 15 cm proximal to the radial styloid process before and 24 hours after PCI.

Results: Among 70 patients, 69 achieved successful dTRA puncture and catheterization (98.6% success rate). Of 67 patients evaluated for secondary PCI, 66 successfully completed the procedure (98.5% success rate). Significant differences between groups were observed in age, platelet count, and incidence of diabetes, left main lesions, and chronic total occlusion ($P<0.05$). All patients had compression bandages removed at 3 hours post-procedure, with palpable radial artery pulsation immediately and at 24 hours post-procedure. No radial artery occlusion occurred, yielding a 100.0% patency rate (69/69). Intergroup comparisons revealed that radial artery inner diameters at 5 cm, 10 cm, and 15 cm proximal to the radial styloid process were significantly larger in the $ $30 days group than in the >30 days group both before and 24 hours after PCI ($P<0.05$). Intragroup comparisons showed that in the $ $30 days group, the radial artery diameter at 15 cm proximal to the radial styloid process decreased at 24 hours post-procedure compared to pre-procedure, while in the >30 days group, the diameter at 5 cm proximal to the radial styloid process increased at 24 hours post-procedure ($P<0.05$).

Conclusion: Secondary PCI via dTRA is safe and feasible. Regardless of whether the interval since the first dTRA PCI is $ $30 days or >30 days, vascular conditions meet the requirements for secondary dTRA PCI. Clinical decisions regarding timing should be based on patient condition and puncture site characteristics.

Keywords: Coronary disease; Coronary artery disease; Percutaneous coronary intervention; Radial artery; Distal radial artery; Reoperation; Treatment outcome; Safety

Introduction

The distal transradial approach (dTRA) utilizes the radial artery in the anatomical snuffbox region or the hegu point area distal to the superficial palmar arch as the puncture site for vascular access. Kiemeneij first reported PCI via dTRA in 2017. Studies have demonstrated that dTRA effectively reduces radial artery occlusion and forearm hematoma rates while improving intraoperative and postoperative patient comfort, benefiting patients who may require future arteriovenous fistula creation for hemodialysis or use of the radial artery as an autologous bypass graft. Recent research has shown that dTRA can safely and effectively perform not only coronary angiography and simple coronary lesions but also complex lesions such as chronic total occlusion (CTO), and can be applied in patients with acute myocardial infarction complicated by hemodynamic instability, low body mass index (BMI<18.5 kg/m^2), and radial artery occlusion.

Previous studies have confirmed that transradial PCI causes acute radial artery injury and intimal thickening, with repeated transradial PCI being an independent risk factor for intimal hyperplasia. However, the distal radial artery is relatively thin, raising questions about whether secondary PCI via dTRA is safe and feasible given the smaller puncture area. Currently, no domestic studies have reported on the feasibility, safety, or timing of secondary PCI via dTRA. This retrospective study aims to explore these aspects.

Methods

Study Subjects

We consecutively enrolled 70 patients scheduled for secondary PCI via dTRA at Fuwai Hospital, Chinese Academy of Medical Sciences between July 2021 and July 2022. Patients were divided into two groups based on the interval since their last dTRA PCI: the $ $30 days group (n=33) and the >30 days group (n=37). Inclusion criteria were: (1) age 18-80 years, any gender; (2) height $ $180 cm; (3) palpable radial artery pulsation in the snuffbox or hegu point area confirmed by palpation before procedure. Exclusion criteria were: (1) primary PCI for acute myocardial infarction; (2) secondary PCI not performed via dTRA. This study was approved by the Fuwai Hospital Ethics Committee (Approval Nos. 2017-860, 2021-1501).

Procedures

Preoperative Phase **General Clinical Data Collection**: We collected demographic characteristics (age, gender, height, weight), history of transradial PCI, time since first dTRA PCI, number of transradial PCI procedures, coronary artery bypass grafting (CABG) history, smoking history, comorbidities (hypertension, diabetes, hyperlipidemia, peripheral vascular disease), clinical diagnosis (stable angina, unstable angina, acute non-ST-segment elevation myocardial infarction, acute ST-segment elevation myocardial infarction), laboratory parameters (creatinine, activated partial thromboplastin time, hemoglobin, platelet count, ascending aortic diameter, left ventricular ejection fraction), and antithrombotic medication use.

Radial Artery Ultrasound Examination: Pre-procedure ultrasound examination of the puncture-side radial artery was performed to measure inner diameters at 5 cm, 10 cm, and 15 cm proximal to the radial styloid process. Two ultrasound machines were used: (1) ProSound 880 color ultrasound diagnostic system with UST-52105 probe (1-5 MHz); (2) Philips iE33/epic 7/epic 7c color Doppler ultrasound diagnostic system with L12-3 probe (5-13 MHz). To ensure data comparability, the same machine was used for pre- and post-procedure measurements in each patient. To ensure adequate radial artery dilation during measurement, patients were given 0.5 mg nitroglycerin sublingually before ultrasound examination.

Intraoperative Phase Based on distal radial artery pulsation or ultrasound findings, the puncture side and site were selected. All patients in this study underwent puncture in the snuffbox region. The anatomical snuffbox is defined as the triangular depression bounded by the extensor pollicis longus tendon, abductor pollicis longus tendon, extensor pollicis brevis tendon, and radial styloid process, where the distal radial artery pulsation can be palpated. Before puncture, patients were instructed to hold their thumb in the palm to expose the puncture site and flatten the snuffbox region for easier palpation and puncture. Based on lesion characteristics and PCI requirements, either 6F or 7F domestic thin-walled sheaths (Hunan Aipute Company) were selected. Intraoperative heparin 100 U/kg and nitroglycerin 100-200 g were administered, with additional heparin 1,000 U administered for each hour of procedure time beyond the first hour. Activated clotting time (ACT) was monitored and maintained at 250-300 seconds; for retrograde CTO procedures, ACT was maintained at 300-350 seconds. After completing coronary intervention, radial artery angiography was performed at the radial styloid process with additional nitroglycerin 100-200 g administered at the brachial artery. Following procedure completion, the sheath was removed and "cross" compression bandaging with gauze and elastic bandage was applied. All puncture and procedural operations were performed by interventional cardiologists from Fuwai Hospital with $ $3 years of independent PCI experience, proficient in dTRA puncture technique, and completing $ $30 dTRA PCI cases annually.

Procedure-related metrics were recorded including puncture site, number of puncture attempts, puncture time, coronary angiography time, PCI time, radiation dose, radiation exposure time, intravascular imaging (IVUS or OCT) usage, angiographic catheter size, guiding catheter size, sheath size, intraoperative sheath exchange, pre-angiography nitroglycerin usage, evaluation for secondary PCI, and dTRA-related complications. Coronary lesion characteristics were assessed based on angiographic results and American College of Cardiology/American Heart Association (ACC/AHA) lesion classification.

Postoperative Phase Post-procedure compression bandaging time was recorded, with observation for bleeding, oozing, forearm pain, swelling, or numbness. If no oozing, hematoma, or bleeding signs were present at 3 hours post-procedure, compression bandaging was removed; if bleeding or mild hematoma persisted, compression was reapplied for 30-60 minutes. At 24 hours post-procedure, ultrasound evaluation of puncture-side radial artery pulsation was performed, with inner diameter measurements at 5 cm, 10 cm, and 15 cm proximal to the radial styloid process. Before examination, patients received 0.5 mg nitroglycerin sublingually.

Statistical Analysis

Data were analyzed using SPSS 26.0 statistical software. For continuous variables, normality was tested first; normally distributed data were expressed as mean $\pm$ standard deviation and analyzed using independent samples t-test and paired t-test. Non-normally distributed data were expressed as median (P25, P75) and analyzed using Wilcoxon rank-sum test. Categorical data were expressed as frequencies and percentages and analyzed using ^{2} test. $P<0.05$ was considered statistically significant.

Results

General Clinical Data

Significant differences between groups were observed in age, diabetes incidence, and platelet count ($P<0.05$). No significant differences were found in gender, height, weight, BMI, history of transradial PCI, number of transradial PCI procedures, CABG history, smoking history, hypertension incidence, hyperlipidemia incidence, peripheral vascular disease incidence, clinical diagnosis, creatinine, activated partial thromboplastin time, hemoglobin, ascending aortic diameter, left ventricular ejection fraction, or antithrombotic medication use ($P>0.05$) .

Procedure-Related Indicators

Except for one patient in the >30 days group who had successful puncture but difficult guidewire placement requiring conversion to conventional transradial approach, all other patients achieved successful dTRA puncture and catheterization (98.6% success rate, 69/70). Among 69 successful dTRA cases, one patient in each group did not undergo secondary PCI due to previous percutaneous transluminal coronary angioplasty with mild residual stenosis. Therefore, 67 patients were evaluated for secondary PCI, with 66 successfully completing the procedure (98.5% success rate, 66/67). No significant differences were observed between groups in puncture site, number of puncture attempts, puncture time, coronary angiography time, PCI time, radiation dose, radiation exposure time, intravascular imaging usage, angiographic catheter size, guiding catheter size, sheath size, intraoperative sheath exchange rate, proportion requiring secondary PCI, pre-angiography nitroglycerin usage, or dTRA-related complication rates ($P>0.05$) .

Coronary Artery Lesions

No significant differences were found between groups in left main lesion or CTO incidence ($P>0.05$). However, significant differences were observed in number of diseased vessels and ACC/AHA lesion classification ($P<0.05$) .

Radial Artery Inner Diameters

All patients had compression bandages removed at 3 hours post-procedure, with palpable puncture-side radial artery pulsation immediately and at 24 hours post-procedure. No radial artery occlusion occurred, yielding a 100.0% patency rate (69/69). Intergroup comparisons showed that radial artery inner diameters at 5 cm, 10 cm, and 15 cm proximal to the radial styloid process were significantly larger in the $ $30 days group than in the >30 days group both before and 24 hours after PCI ($P<0.05$). Intragroup comparisons revealed that in the $ $30 days group, the radial artery diameter at 15 cm proximal to the radial styloid process decreased at 24 hours post-procedure compared to pre-procedure, while in the >30 days group, the diameter at 5 cm proximal to the radial styloid process increased at 24 hours post-procedure ($P<0.05$). No significant differences were observed in other intragroup comparisons .

Discussion

Effectiveness of Secondary PCI via dTRA

Compared with transfemoral approach, transradial PCI offers advantages including no requirement for bed rest and fewer bleeding and vascular complications. Consequently, domestic and international guidelines recommend transradial approach as the first choice for both elective and emergency PCI. However,

transradial approach carries certain complication risks, with radial artery occlusion being the most common. Although radial artery occlusion has minimal impact on hand sensory and motor function due to dual blood supply, some patients experience forearm pain in the radial artery distribution. Moreover, radial artery occlusion affects future transradial coronary and peripheral vascular interventions, use as autologous coronary bypass graft conduit, and creation of arteriovenous fistulas for long-term hemodialysis. Since Kiemeneij first reported dTRA for PCI in 2017, numerous studies have confirmed that dTRA is not only safe but also applicable to complex coronary lesions, with increased patient comfort during and after procedure, shorter post-procedure compression time, minimal impact on hand function, and significantly reduced radial artery occlusion rates.

Safety of Secondary PCI via dTRA

Previous dTRA studies have primarily focused on chronic coronary artery disease patients, with relatively low proportions undergoing PCI. In this study, 66 patients successfully completed secondary PCI with a success rate of 98.5% (66/67). Ferrante et al. conducted a meta-analysis of 14 randomized controlled trials and found that although dTRA effectively reduced radial artery occlusion and EASY grade ≥II forearm hematoma, it increased crossover risk. Other studies identified female sex and systolic blood pressure <120 mmHg as independent predictors of dTRA puncture failure. Our results showed no significant differences in procedure-related indicators between groups, suggesting that timing does not affect technical metrics for secondary dTRA PCI. One patient in the >30 days group had successful puncture but difficult guidewire placement requiring conversion to conventional transradial approach. One patient in the $ $30 days group developed hand and forearm swelling classified as EASY grade II-III, which gradually resolved with limb elevation and topical medication. No radial artery occlusion occurred in either group, demonstrating that secondary PCI via dTRA is safe and feasible. However, due to the small sample size and few dTRA puncture/catheterization failures, we could not analyze factors influencing secondary dTRA PCI failure, warranting larger sample studies.

Impact of Timing of Initial dTRA PCI on Secondary PCI

Vascular injury and reactive hyperplasia after transradial PCI causing luminal narrowing are important factors influencing secondary PCI timing. Invasive and non-invasive imaging studies have shown acute radial artery injury and intimal thickening after transradial PCI. Yonetsu et al. used optical coherence tomography to demonstrate that transradial PCI causes radial artery intimal tears, medial dissection, intramural hematoma, and thrombus formation. Intimal tears predominantly occur in the distal radial artery (near puncture site), while medial dissection commonly occurs in proximal and distal segments. Proximal medial dissection is located near the radial artery bifurcation (sheath tip [3.9$±$1.4] cm from radial artery origin), primarily related to catheter/guidewire manipulation

after sheath insertion, whereas distal medial dissection is mainly associated with puncture and sheath placement. Studies have shown that repeated transradial PCI further increases acute radial artery injury risk, with significantly greater intima/media area ratio, intima/media thickness ratio, and stenosis severity compared to initial transradial PCI, making repeated transradial PCI an independent risk factor for radial artery intimal thickening.

Given that radial artery injury typically normalizes within 30 days post-procedure, we used 30 days as the cutoff to divide patients into $ $30 days and >30 days groups. Results showed that radial artery inner diameters at 5 cm, 10 cm, and 15 cm proximal to the radial styloid process were larger in the $ $30 days group than in the >30 days group before and after PCI, likely due to reactive intimal and wall thickening. In the $ $30 days group, the diameter at 15 cm proximal to the radial styloid process decreased at 24 hours post-procedure, likely because the radial artery dilation effect from the recent procedure had not completely resolved, making diameters significantly larger than the 6F sheath outer diameter (2.45 mm) with minimal sheath impact, though PCI manipulation may cause acute injury at the sheath tip. In the >30 days group, the diameter at 5 cm proximal to the radial styloid process increased at 24 hours post-procedure, likely due to radial artery recoil causing sheath-induced dilation. Therefore, regardless of whether the interval since first dTRA PCI is $ $30 days or >30 days, vascular conditions meet requirements for secondary dTRA PCI.

Shorter compression time is crucial for preventing radial artery occlusion after dTRA PCI. The DISCO study demonstrated that shortening radial artery compression time (<2 hours) using non-occlusive hemostasis effectively prevents radial artery occlusion, with radial artery occlusion rate reduced to 0.91% (6/657) when following optimized compression protocols. In contrast, 14.8% (13/88) of patients with 3-hour compression after transradial PCI had immediate pseudoaneurysm detection, with 55.8% (49/88) progressing to pseudoaneurysm at 30-day follow-up, likely due to inadequate compression. Notably, most transradial PCI patients in clinical practice require at least 8 hours of compression, which is difficult to achieve with only 2 hours of compression and may increase patient burden and healthcare workload. Due to the anatomical characteristics and dual blood supply of the distal radial artery, dTRA PCI allows shorter compression time while maintaining hemostasis and preserving proximal radial artery patency, preventing occlusion. Our team recently found that using 5F angiographic catheters for coronary angiography via dTRA with 2-hour compression is safe and feasible. In this study, both groups had compression bandages removed at 3 hours post-procedure with 100% radial artery patency, though this exceeds the previously recommended 2 hours and requires further optimization.

Skilled Puncture as a Critical Factor for Successful Secondary dTRA PCI

Costa et al. found that the number of transradial puncture attempts correlates with puncture complications including radial artery occlusion and loss of pulsation. Compared with conventional transradial approach, dTRA has a steeper learning curve. All procedures in this study were performed by experienced interventional cardiologists from Fuwai Hospital with $ $3 years of independent PCI experience, proficient in dTRA technique and completing $ $30 dTRA PCI cases annually, ensuring minimal puncture attempts and distal radial artery injury. The puncture site is approximately 5 cm from the proximal radial artery, providing sufficient working length to reduce radial artery injury from puncture or guidewire manipulation. Nevertheless, operator proficiency should be considered when promoting secondary dTRA PCI, with recommendation for experienced operators to perform these procedures.

In summary, secondary PCI via dTRA is safe and feasible for complex coronary lesions including left main disease, three-vessel disease, and CTO. Regardless of whether the interval since first dTRA PCI is $ $30 days or >30 days, vascular conditions meet requirements for secondary dTRA PCI, and timing should be determined based on patient condition and puncture site characteristics.

Limitations

This study has several limitations. First, it is a single-center retrospective study with small sample size and short follow-up duration; results require validation through multicenter, prospective, large-scale studies. Second, imaging assessment of radial arteries was limited to diameter measurement by ultrasound; future studies should utilize multimodal imaging to evaluate functional impact of secondary dTRA PCI on radial arteries. Third, significant differences existed between groups in age, diabetes incidence, and platelet count, and antithrombotic therapy intensity was not high. Future studies should investigate the impact of anticoagulation or intensified antiplatelet therapy on secondary dTRA PCI patients.

Author Contributions

LIU Minghao, WANG Pan, and GAO Lijian were responsible for study conception, design, and feasibility analysis. LIU Minghao, WANG Pan, XU Shuqing, WANG Huanhuan, and ZHAO Guangxian collected and organized literature/data and drafted the manuscript. LIU Minghao and GAO Lijian revised the manuscript and English translation. GAO Lijian, CHEN Jue, QIAO Shubin, XU Bo, and YUAN Jinqing were responsible for quality control and critical review. GAO Lijian had overall responsibility for the article and supervised the study.

Conflict of Interest: The authors declare no conflict of interest.

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Note: Figure translations are in progress. See original paper for figures.