Feasibility of Retrograde Recanalization of Occluded Radial Artery via Distal Transradial Access: A Single-Center Prospective Study Post-Print

Authors: Yuan Mingpei, Lin Yaowang, Bei Weijie, Liu Huadong, Dong Shaohong, Sun Xin, Sun Xin

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Abstract

Background: The incidence of radial artery occlusion (RAO) following coronary interventional procedures via transradial access is relatively high; however, large-sample, long-term follow-up studies investigating retrograde recanalization of occluded radial arteries via distal transradial access (dTRA) are currently lacking. Objective: To evaluate the feasibility of retrograde recanalization of occluded radial arteries via dTRA. Methods: Consecutive patients (n=44) who developed RAO after undergoing coronary interventional procedures via transradial access (TRA) and were admitted to the Department of Cardiology at Shenzhen People' s Hospital between June 2019 and December 2021 were enrolled. Based on the outcome of retrograde recanalization of the occluded radial artery via dTRA, patients were divided into a success group (n=39) and a failure group (n=5). The primary endpoint was the success rate of retrograde recanalization via dTRA, while secondary endpoints included possible predictive factors for failure of retrograde recanalization via dTRA, incidence of in-hospital complications, and radial artery patency rates at 3, 6, and 12 months postoperatively. Results: The success rate of retrograde recanalization of occluded radial arteries via dTRA in this study was 88.6% (39/44). The failure group exhibited higher proportions of patients with a history of diabetes, smoking rates, proportion of patients with $ $3 previous coronary interventional procedures, and proportion of patients with chronic total coronary occlusion, while the proportion of patients undergoing balloon angioplasty was lower compared to the success group ($P<0.05$). No statistically significant difference was observed in the incidence of puncture site bleeding or hematoma between the two groups during hospitalization ($P>0.05$). The radial artery patency rates in the success group at 3, 6, and 12 months postoperatively were 48.7% (19/39), 43.6% (17/39), and

35.9% (14/39), respectively. Conclusion: Retrograde recanalization of occluded radial arteries via dTRA is feasible, with a high success rate of 88.6%; however, the long-term patency rate is below 50.0%. Diabetes, smoking, $ $3 previous coronary interventional procedures, chronic total coronary occlusion, and absence of balloon angioplasty may be predictive factors for failure of retrograde recanalization via dTRA. It is recommended that patients with RAO requiring elective coronary interventional procedures undergo retrograde recanalization of the occluded radial artery via dTRA.

Full Text

Preamble

Expert Profile

Sun Xin, MD, PhD, is an Associate Chief Physician and Master' s Supervisor at Shenzhen People' s Hospital. He specializes in the diagnosis and treatment of cardiovascular diseases, medical education, and research, with a focus on interdisciplinary integration and translational research across medicine, engineering, and science. His expertise includes emergency cardiovascular care and coronary interventional diagnosis and treatment. He serves as Deputy Leader of the Hemodynamics and Critical Care Ultrasound Group of the Cardiac Critical Care Branch of Guangdong Medical Doctor Association, Committee Member of the Cardiology Branch of Guangdong Medical Doctor Association, Youth Committee Member of the Cardiovascular Branch of Guangdong Medical Association, and Secretary of the Thumb Distal Radial Artery Club. He is a Shenzhen High-Level Talent, Shenzhen Health Excellence Talent, and Shenzhen Outstanding Youth. He has led 9 research projects including the National Natural Science Foundation Youth and General Programs. He has published 35 SCI-indexed articles, 16 as first or corresponding author, holds 5 national invention and utility model patents, and received 4 provincial science and technology awards including First Prize. He serves as Youth Editorial Board Member of *Journal of Geriatric Cardiology* and Corresponding Editorial Board Member of *Chinese Journal of Cardiology (Online Edition)*.

Article Information

Title: Feasibility of Retrograde Recanalization of Occluded Radial Artery via Distal Transradial Artery Approach: A Single-Center Prospective Study

Authors: YUAN Mingpei[12], LIN Yaowang[12], BEI Weijie[12], LIU Huadong[12], DONG Shaohong[12], SUN Xin[12]*

Affiliations: [1]Department of Cardiology, Shenzhen People' s Hospital/The Second Clinical Medical College of Jinan University/The First Affiliated Hospital of Southern University of Science and Technology, Shenzhen 518020, China; [2]Cardiovascular Minimally Invasive Medical Engineering Technology Research and Development Center, Shenzhen 518020, China

Corresponding Author: SUN Xin, Associate Chief Physician; E-mail: sunxinflying@163.com

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Abstract

Background: The incidence of radial artery occlusion (RAO) following coronary interventional procedures via transradial artery approach (TRA) is high. However, large-sample, long-term follow-up studies on retrograde recanalization of occluded radial artery via distal transradial artery approach (dTRA) are lacking.

Objective: To evaluate the feasibility of retrograde recanalization of occluded radial artery via dTRA.

Methods: We prospectively enrolled 44 consecutive patients who developed RAO after undergoing coronary interventional procedures via TRA at the Department of Cardiology, Shenzhen People' s Hospital between June 2019 and December 2021. Patients were divided into a successful group (n=39) and a failed group (n=5) based on the outcome of dTRA retrograde recanalization. The primary endpoint was the success rate of retrograde recanalization of occluded radial artery via dTRA. Secondary endpoints included possible predictors of failed recanalization, incidence of in-hospital complications, and radial artery patency rates at 3, 6, and 12 months post-procedure.

Results: The success rate of retrograde recanalization via dTRA was 88.6% (39/44). The failed group had significantly higher proportions of patients with diabetes history, smoking, prior coronary interventions $ $3 times, and chronic coronary total occlusion, along with a significantly lower proportion of patients undergoing balloon angioplasty ($P<0.05$). There was no significant difference in the incidence of puncture site bleeding or hematoma between the two groups during hospitalization ($P>0.05$). In the successful group, radial artery patency rates at 3, 6, and 12 months were 48.7% (19/39), 43.6% (17/39), and 35.9% (14/39), respectively.

Conclusion: Retrograde recanalization of occluded radial artery via dTRA is feasible with a high procedural success rate of 88.6%, but the long-term patency rate is below 50.0%. Diabetes, smoking, prior coronary interventions $ $3 times, chronic coronary total occlusion, and absence of balloon angioplasty may be predictors of failed recanalization. dTRA retrograde recanalization is recommended for RAO patients who also require elective coronary intervention.

Keywords: Coronary disease; Coronary artery disease; Percutaneous coronary intervention; Coronary angiography; Arterial occlusive diseases; Distal radial artery; Radial artery occlusion; Prospective studies; Feasibility studies

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Main Text

Compared with transfemoral approach, transradial artery approach (TRA) for coronary interventional procedures is associated with fewer complications and accounts for over 90% of coronary interventions [1]. However, the incidence of radial artery occlusion (RAO) following TRA remains high. The PROPHET study demonstrated that the incidence of RAO at 24 hours and 30 days after transradial catheterization was 12% and 7%, respectively [2]. Once RAO occurs, the radial artery can no longer be used for repeat TRA coronary interventions, nor can it serve as an arterial graft for coronary artery bypass surgery or as a backup artery for arteriovenous fistula creation in hemodialysis patients.

The distal radial artery refers to the segment of radial artery distal to the superficial palmar branch. Clinical practice has confirmed that coronary interventional procedures via distal transradial artery approach (dTRA) are safe and effective, offering improved patient comfort, shorter compression time, and reduced bleeding complications and RAO incidence. Moreover, due to dual blood supply to the distal radial artery, blood can reach this segment via the superficial and deep palmar arches even after RAO, enabling successful dTRA puncture and subsequent recanalization of the occluded segment. In 2018, BALABAN et al. [4] (n=25) demonstrated that retrograde recanalization of RAO via dTRA for coronary angiography was safe and feasible. In 2021, SHI et al. [5] (n=15) confirmed that dTRA for occluded radial artery recanalization was safe and effective. However, large-sample, long-term follow-up studies on retrograde recanalization of occluded radial artery via dTRA are currently lacking. This single-center prospective study enrolled 44 patients who developed RAO after TRA coronary interventions, performed retrograde recanalization of the occluded radial artery via dTRA, and conducted 12-month follow-up to evaluate the feasibility of this approach.

1.2 Methods

We used the Cordis Avanti radial artery puncture kit for all procedures. The technique involved: (1) Palpating the distal radial artery pulse in the anatomical snuffbox or Hegu acupoint region and selecting the site with the strongest pulsation as the puncture point; (2) Administering 2-3 ml of lidocaine for local anesthesia and performing puncture using the modified Seldinger technique; (3)

After successful puncture, making a skin incision with a blade and advancing the radial artery sheath along the guidewire into the artery to a depth of 2-3 cm [Figure 1: see original paper]A, then injecting heparin 70-100 U/kg through the sheath; (4) Performing radial artery angiography to visualize the radial artery, occlusion site, thrombus burden, and collateral circulation [Figure 1: see original paper]B, C. For acute occlusion or chronic occlusion with high thrombus burden, thrombus aspiration was performed directly through the radial artery sheath (preferably a 7F thin-walled sheath) or aspiration catheter [Figure 1: see original paper]D. For chronic occlusion without thrombus burden or when aspiration was unsuccessful or flow restoration was inadequate after aspiration, balloon angioplasty was performed [Figure 1: see original paper]E, with assistance from 0.014 or 0.025 guidewires if necessary; (5) For acute occlusion or chronic occlusion with high thrombus burden, continuous thrombolytic therapy with urokinase was administered for 6-12 hours via microcatheter (Terumo, Japan) [Figure 1: see original paper]F after recanalization; (6) Final radial artery angiography was performed to confirm restoration of antegrade flow [Figure 1: see original paper]G. All dTRA retrograde recanalization procedures were performed by the same experienced physician.

1.3 Study Endpoints

The primary endpoint was the success rate of retrograde recanalization of occluded radial artery via dTRA. Successful recanalization was defined as restoration of antegrade flow confirmed by radial artery angiography and Doppler ultrasound. Failed recanalization was defined as failure to restore antegrade flow confirmed by radial artery angiography. Secondary endpoints included possible predictors of failed recanalization, incidence of in-hospital complications (including puncture site bleeding and hematoma), and radial artery patency rates at 3, 6, and 12 months post-procedure. Patency was assessed by Doppler ultrasound (Handydop Pro, Medisound Medical Device) during outpatient follow-up.

Statistical Analysis

All continuous variables in this study followed normal distribution and were expressed as mean ± standard deviation ($\bar{x}\pm s$), analyzed using independent samples t-test. Categorical variables were expressed as percentages and analyzed using ^{2} test or Fisher' s exact test. $P<0.05$ was considered statistically significant.

2.1 Success Rate of dTRA Retrograde Recanalization

The success rate of retrograde recanalization via dTRA was 88.6% (39/44).

2.2 Predictors of Failed dTRA Recanalization

2.2.1 General Clinical Characteristics There were no significant differences between groups in age, male proportion, body mass index, intraoperative

systolic blood pressure, intraoperative heart rate, hypertension history, coronary artery disease diagnosis, or treatment plan (P>0.05). However, the failed group had significantly higher proportions of patients with diabetes history, smoking, prior coronary interventions $ $3 times, and chronic coronary total occlusion compared with the successful group (P<0.05). The proportion of patients undergoing balloon angioplasty was lower in the failed group .

2.2.2 Procedure Characteristics There were no significant differences between groups in procedure time, auxiliary guidewire usage, proportion using balloon assistance, proportion undergoing thrombus aspiration, or total procedure cost (P>0.05). The proportion of patients undergoing balloon angioplasty was significantly lower in the failed group (P<0.05) .

2.3 In-Hospital Complications

During hospitalization, one patient in the successful group and one in the failed group experienced minor puncture site bleeding, and one patient in each group developed puncture site hematoma. There were no significant differences in the incidence of puncture site bleeding (Fisher' s exact test ^{2}=1.320, P=0.082) or hematoma (Fisher' s exact test ^{2}=1.320, P=0.082) between groups.

2.4 Radial Artery Patency Rates

All patients in the successful group completed outpatient follow-up without loss to follow-up. Radial artery patency rates at 3, 6, and 12 months were 48.7% (19/39), 43.6% (17/39), and 35.9% (14/39), respectively.

Discussion

RAO is a common complication after TRA coronary interventions, with reported incidence ranging from 0.8% to 38.0% [6-7]. Studies have shown that factors associated with RAO include body mass index, diabetes, sheath size, anticoagulant use, and compression time [6,8]. For patients with RAO, although dual blood supply via the palmar arch rarely causes severe hand ischemia, it may affect arm strength activities or cause severe pain due to acute occlusion. Moreover, RAO limits repeat TRA coronary interventions. While transfemoral approach can serve as an alternative, it carries higher complication risks and lower patient comfort [9]. Additionally, for patients with renal insufficiency, RAO eliminates the opportunity to use the radial artery as a backup artery for arteriovenous fistula creation [10].

Since 2017, dTRA has emerged as a novel approach for coronary interventions, attracting considerable attention from interventional cardiologists for its advantages and potential benefits [3,11-12]. Several investigators have explored the feasibility of retrograde recanalization of occluded radial artery via dTRA. SHEIKH et al. [13] reported in 2018 a case of successful left RAO recanalization

via dTRA in a patient with prior coronary artery bypass surgery, multiple coronary interventions, and severe peripheral vascular disease. LI et al. [14] reported in 2021 a case of successful radial artery recanalization via dTRA in a patient who developed RAO after emergency percutaneous coronary intervention. Additionally, small-sample clinical studies have confirmed that dTRA retrograde recanalization of occluded radial artery is safe and effective, with success rates ranging from 88% to 93% [4-5]. Our study' s success rate of 88.6% aligns with these reports.

Further analysis of predictors for failed dTRA recanalization revealed that the failed group had higher proportions of diabetes history, smoking, prior coronary interventions $ $3 times, chronic coronary total occlusion, and lower proportion of balloon angioplasty. Given that these factors are associated with radial artery spasm, calcification, and poor collateral circulation, they may serve as predictors of failed dTRA recanalization.

Puncture site bleeding and hematoma are the most common complications of dTRA puncture [4,15], but the incidence is lower compared with TRA puncture [16]. To improve dTRA puncture success rate, four aspects should be emphasized: First, operators should possess extensive dTRA puncture experience with high success rates. Second, ultrasound guidance can improve dTRA puncture success rate [17-18] and should be actively employed when available. Third, the sheath should be advanced 2-3 cm into the distal radial artery, not too deep. If no blood return is observed after sheath withdrawal, confirmation is needed whether the sheath is within the occluded segment or thrombus rather than in a false lumen. Finally, balloon tracking technique can assist guidewire passage through the occluded segment [5].

The long-term prognosis of retrograde recanalization for RAO remains unclear. BALABAN et al. [4] reported that among 14 RAO patients receiving drug-coated balloon therapy during the procedure, radial artery patency at 1 month was only 33.4%. Our study showed patency rates of 48.7%, 43.6%, and 35.9% at 3, 6, and 12 months, respectively, which are higher than BALABAN' s report despite our patients not receiving drug-coated balloon therapy. This discrepancy may be attributed to different mechanisms of arterial stenosis formation. Previous studies have shown that drug-coated balloon therapy is effective and durable for preventing atherosclerosis-induced arterial stenosis but less effective in dysfunctional dialysis access or RAO caused by repeated punctures [19-20]. However, the role of drug-coated balloon therapy in maintaining radial artery patency requires further confirmation through randomized controlled trials.

It should be noted that given the relatively low postoperative radial artery patency rate, dTRA retrograde recanalization may be more suitable for RAO patients who also require elective coronary intervention. Since the instruments and materials used for RAO recanalization can continue to be used for subsequent coronary interventions, this approach may also reduce procedure costs. For asymptomatic RAO patients without coronary intervention needs within one year, simple dTRA retrograde recanalization may not be beneficial for main-

taining radial artery patency.

This study has several limitations: (1) The small number of patients in the failed group (n=5) precluded multivariate logistic regression and propensity-matched analyses to identify predictors of failed dTRA recanalization; (2) We did not compare drug-coated balloons with conventional balloons to determine their applicability in RAO treatment; (3) We did not analyze vascular parameters obtained by Doppler ultrasound, such as radial artery diameter before and after the procedure; (4) This is a single-center study, and the results and conclusions require validation by larger-scale, multicenter randomized controlled trials.

In conclusion, retrograde recanalization of occluded radial artery via dTRA is feasible with a high procedural success rate of 88.6%, but the long-term patency rate is below 50.0%. Diabetes, smoking, prior coronary interventions $ $3 times, chronic coronary total occlusion, and absence of balloon angioplasty may be predictors of failed recanalization. For RAO patients who also require elective coronary intervention, dTRA retrograde recanalization is recommended.

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Author Contributions: YUAN Mingpei was responsible for feasibility analysis, literature search, statistical analysis, and manuscript writing. LIN Yaowang, BEI Weijie, LIU Huadong, and DONG Shaohong collected and organized data and conducted patient follow-up. LIN Yaowang revised the manuscript and was responsible for quality control and review. SUN Xin conceived the study, established overall research objectives, and took overall responsibility for the article.

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