



ORIGINAL STUDIES

Feasibility and safety of the successive use of distal transradial access for coronary angiography and intervention in the same arm

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[Correction added on September 02, 2021,
after first online publication: The copyright
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Abstract

Distal transradial access (dTRA) is a novel alternative to conventional radial artery access for coronary catheterization. However, the feasibility and safety of repeated use of dTRA have not been fully elucidated. This study aimed to evaluate the feasibility and safety of the repeated use of dTRA for coronary angiography and intervention in the same arm. A total of 1717 patients underwent angiography or angioplasty via dTRA. We retrospectively analyzed the catheterization records of patients who underwent repeated puncture of the distal radial artery in the same arm. The incidence of successive applications of dTRA and the reasons for dropout were retrospectively investigated. A total of 416 patients, including three who underwent coronary catheterization with the bilateral dTRA in the initial attempt were analyzed. A 3-, 4-, 5-, or 6-French sheath or sheathless guide catheter was used in the initial procedure. A maximum of four successive coronary catheterization procedures were performed. The second procedure with dTRA on the same arm was successfully performed in 395 cases (94.3%), with a successive rate of 89.6% for both the third and fourth dTRA procedures. Conversion to another approach site ($n = 30$) was attributed to radial artery occlusion ($n = 9$), narrowing of the distal radial artery ($n = 19$), and puncture failure ($n = 2$). The current data indicate that the repeated use of dTRA is safe and feasible, and this approach may become a standard approach site in the future.

KEYWORDS

distal radial artery, distal transradial access

1 | INTRODUCTION

Transradial access (TRA) for coronary angiography and intervention has demonstrated advantages over transfemoral access (TFA) not only in bleeding complications, but also in mortality.¹ Therefore, TRA has

become a standard approach for coronary angiography and intervention, which is described as a class I recommendation in the latest ESC/EACTS guidelines.² However, radial artery occlusion (RAO) after TRA is problematic because of the smaller caliber of the artery, and the repeated use of TRA is limited. Indeed, a study conducted in

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Japan demonstrated that the repeated use of the radial artery for catheterization is limited to 70% in men and 50% in women at the fourth attempt.³

Recently, distal transradial access (dTRA), also known as snuff box access, was introduced as an alternative to conventional transradial access (cTRA). The advantages of dTRA include a lower rate of hemorrhagic complications, quicker achievement of hemostasis, and less frequent RAO than cTRA.^{4,5} However, little is known about the nature of the successive use of the same radial artery.

In the current study, we sought to evaluate the feasibility and safety of the repeated use of dTRA for coronary angiography and intervention in the same arm.

2 | METHODS

2.1 | Study design and population

This was a single-center retrospective study, and a total of 2406 coronary catheterization procedures performed between April 2018 and March 2020 were investigated. The vascular access sites of the catheterization procedure in these patients were dTRA, cTRA, transbrachial approach, and TFA in 2129 (88.5%), 75 (3.1%), 50 (2.1%), and 152 patients (6.3%), respectively. Among the 1126 patients who underwent dTRA for the first procedure, 430 underwent repeated coronary catheterization (in patients who underwent dTRA procedures from both arms, each procedure was counted separately). Those patients who underwent repeated catheterization with dTRA were analyzed; the incidence of successive dTRA in the same arm and the reasons for access site conversion were investigated. When analyzing the success rate of successive use of the same distal radial artery (DRA), the cases in which the access site was converted because of strategic reasons such as subsequent aortography or bypass graft angiography were excluded. Finally, 416 patients and 419 dTRA procedures were included in the study (Figure 1).

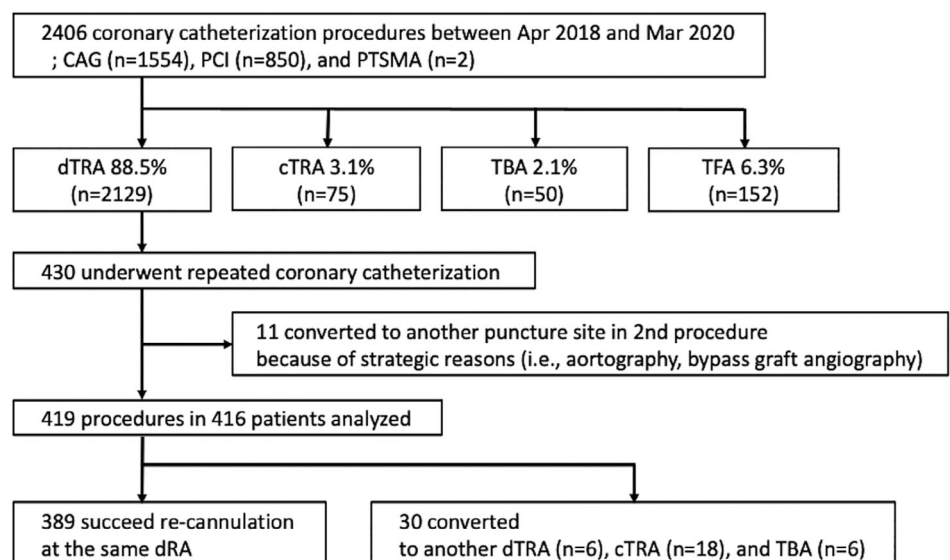
2.2 | Distal radial approach

After skin anesthesia with lidocaine, the DRA was punctured in the anatomical snuff box with a 20-gauge Surflo™ I.V. catheter (Terumo). The puncture was performed with either digital palpation or sonographic guidance at the operator's discretion; when puncture failed with digital palpation, an ultrasound-guided puncture was performed. Furthermore, for patients with cardiogenic shock or cardiac arrest, sonographic guidance with a high-frequency linear transducer was used for the initial attempt. After successful puncture, a dedicated 0.025 inch mini guidewire was inserted up to the brachial artery, and the sheath introducer (4-, 5-, or 6-Fr Radifocus® Introducer, Terumo; 5-, 6-, or 7-Fr Glidesheath Slender®, Terumo; or 3- or 4-Fr Super-sheath®, Medikit) was advanced into the radial artery over the guidewire. If the sheathless technique was applied, a 0.025 inch guidewire was inserted through an 18-gauge Surflo™ I.V. catheter or a previously inserted sheath of a smaller size. A guiding catheter with an inner catheter dedicated to sheathless insertion (5-Fr Works™, Medikit, or 6-Fr Hyperion SheathLess™, Asahi Intecc) was inserted over the guidewire. The right DRA was the primary puncture site in this study.

2.3 | Hemostasis and hemorrhagic complications

After the catheterization procedure was completed, a STEPTY™ hemostatic pad (NICHIBAN Co) was applied at the puncture site before sheath removal. The operators pressed the pad lightly with their thumb and removed the catheter, and then wrapped an elastic bandage around the hand. The compression bandage was released after 2 h in diagnostic procedures and after 3 h in interventional procedures. In cases in which bleeding occurred at the puncture site or swelling with hematoma was detected, additional compression with an elastic bandage was applied until hemostasis was achieved.

FIGURE 1 Study flowchart. CAG, coronary angiography; cTRA, conventional transradial access; dTRA, distal transradial access; PCI, percutaneous coronary intervention; PTSMA, percutaneous transluminal septal myocardial ablation; TBA, transbrachial access; TFA, transfemoral access



2.4 | Access site conversion

The access site for coronary catheterization after the second procedure was determined by the condition of the DRA examined by either the physical examination or sonography findings. If vessel narrowing was detected on ultrasound examination or pulsation in the snuff box was lost, different access sites were selected for subsequent procedures. DRA in the opposite arm was the primary alternative in such cases. In case in which the guidewire insertion failed despite multiple attempts after the second procedure, the access site was also instantaneously converted to another vessel.

2.5 | Ethical considerations

This study was performed in accordance with the Declaration of Helsinki principles, and ethical approval was obtained from the

institutional review board of the authors' hospital. Written informed consent was not necessary for this type of study.

2.6 | Statistical analyses

Categorical variables are expressed as numbers and percentages, and continuous variables are expressed using means and SDs. After testing for normal distributions, differences were compared using the unpaired Student's *t*-test or the Mann-Whitney *U* test, as appropriate. A multivariate logistic regression analysis was conducted for the following three factors: body surface area, procedure time, and sheath size in the initial procedure. All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University; <http://www.jichi.ac.jp/saitama-sct/SaitamaHP.files/statmedEN.html>), a graphical user interface for R (The R Foundation for Statistical Computing, version 3.6.2). More precisely, it is a modified version of

TABLE 1 Patients' background and procedural characteristics

	Overall (n = 419)	Male (n = 318)	Female (n = 101)	p value
Age (years)	71.9 ± 10.8	70.3 ± 10.9	76.9 ± 9.2	<0.001
Height (cm)	162.1 ± 9.1	165.8 ± 6.4	150.3 ± 5.9	<0.001
Weight (kg)	63.6 ± 13.5	67.4 ± 12.0	51.6 ± 11.0	<0.001
Body surface area (m ²)	1.67 ± 0.20	1.74 ± 0.16	1.45 ± 0.14	<0.001
Body mass index (kg/m ²)	24.0 ± 4.2	24.4 ± 4.0	22.9 ± 4.8	0.002
Hemoglobin (g/dl)	13.6 ± 2.0	14.0 ± 2.0	12.4 ± 1.5	<0.001
Serum creatinine (mg/dl)	0.96 ± 0.37	1.00 ± 0.33	0.86 ± 0.45	0.001
Diabetes mellitus	144 (34.4%)	115 (36.2%)	29 (28.7%)	0.187
Hypertension	344 (82.1%)	265 (83.3%)	79 (78.2%)	0.238
Dyslipidemia	320 (76.4%)	251 (78.9%)	69 (68.3%)	0.032
Smoking history	266 (63.5%)	244 (76.7%)	22 (21.8%)	<0.001
Previous MI	80 (19.1%)	71 (22.3%)	9 (8.9%)	0.002
Emergency	97 (23.2%)	76 (23.9%)	21 (20.8%)	0.589
Acute coronary syndrome	96 (22.9%)	80 (25.2%)	16 (15.8%)	0.057
Acute heart failure	18 (4.3%)	13 (4.1%)	5 (5.0%)	0.778
Shock on arrival	4 (1.0%)	3 (0.9%)	1 (1.0%)	1.000
Cardiac arrest	6 (1.4%)	5 (1.6%)	1 (1.0%)	1.000
Use of IABP	9 (2.1%)	8 (2.5%)	1 (1.0%)	0.694
Use of ECMO	3 (0.7%)	3 (0.9%)	0 (0%)	1.000
LV ejection fraction (%)	58.2 ± 12.6	57.8 ± 12.4	59.7 ± 13.0	0.182
Previous radial puncture	133 (31.7%)	112 (35.2%)	21 (20.8%)	0.007
Dose of heparin (U/L)	5720 ± 2923	5871 ± 3001	5248 ± 2621	0.062
Right dRA puncture	380 (90.7%)	292 (91.8%)	88 (87.1%)	0.170
Left dRA puncture	39 (9.3%)	26 (8.2%)	13 (12.9%)	
Ultrasound-guided puncture	192 (45.8%)	143 (45.0%)	49 (48.5%)	0.567
Sheath size ^a				0.001
3-Fr	2 (0.5%)	1 (0.3%)	1 (1.0%)	
4-Fr	301 (71.8%)	223 (70.1%)	78 (77.2%)	
5-Fr	56 (13.4%)	38 (11.9%)	18 (17.8%)	
6-Fr	60 (14.3%)	56 (17.6%)	4 (4.0%)	
Sheathless guide system	8 (1.9%)	5 (1.6%)	3 (3.0%)	0.406
Procedure time (min)	48.9 ± 22.9	49.0 ± 22.0	48.9 ± 25.6	0.977

Note: Values represent mean ± SD or number (%). A two-tailed *p*-value <0.05 was considered statistically significant.

Abbreviations: dRA, distal radial artery; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pumping; LV, left ventricle; MI, myocardial infarction.

^a3Fr size = 4Fr sheathless; 4Fr size = 4Fr conventional sheath, 5Fr slender sheath, or 5Fr sheathless; 5Fr size = 5Fr conventional sheath, 6Fr slender sheath, or 6Fr sheathless; 6Fr size = 6Fr conventional sheath.

R commander (version 2.6-2) that was designed to add statistical functions frequently used in biostatistics.⁶ Statistical significance was set at $p < 0.05$.

3 | RESULTS

3.1 | Patient characteristics

The mean age of the patients was 71.9 ± 10.8 years, and 75.9% were male. The mean height was 162.1 ± 9.1 cm, and the mean weight was 63.6 ± 13.5 kg. Eighty patients (19.1%) had a history of myocardial infarction, and the radial artery on the same side was previously punctured using the conventional radial approach in 133 patients (31.7%). Cardiac catheterization was performed in an emergency setting in 97 patients (23.2%), including 96 patients (22.9%) with acute coronary syndrome. Eighteen patients (4.3%) presented with acute decompensated heart failure, four patients (1.0%) with cardiogenic shock, and six patients (1.4%) with cardiac arrest on arrival at the hospital (Table 1).

3.2 | Procedural characteristics

Right dTRA was performed in 380 patients (90.7%), and ultrasound-guided puncture was performed in 192 patients (45.8%). A sheathless guide system was applied in eight patients (1.9%). The size of the sheath

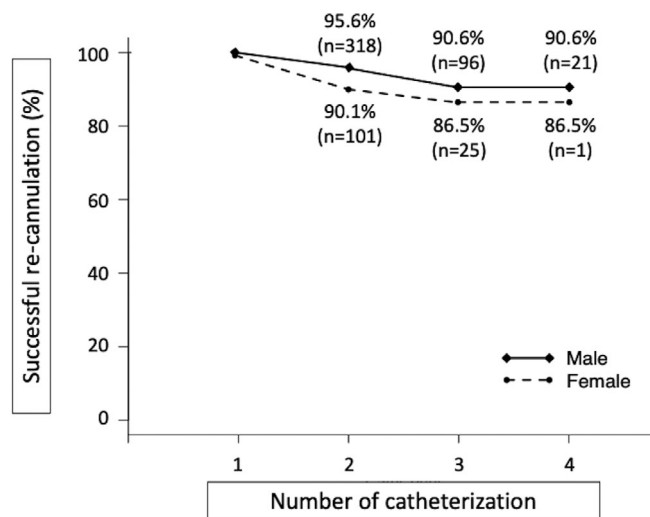


FIGURE 2 Successive rate of distal transradial access in the same arm

TABLE 2 Reason for access site conversion

No of attempt	2nd (n = 419)	3rd (n = 121)	4th (n = 22)	Overall (n = 419)
Vessel occlusion	8 (1.9%)	1 (0.8%)	0 (0%)	9 (2.1%)
Vessel narrowing	15 (3.6%)	4 (3.3%)	0 (0%)	19 (4.5%)
Puncture failure	1 (0.2%)	1 (0.8%)	0 (0%)	2 (0.5%)

Note: Values represent number (%). The percentage corresponds to the whole cohort.

introducer was 3-Fr, 4-Fr, 5-Fr, and 6-Fr in two (0.5%), 301 (71.8%), 56 (13.4%), and 60 patients (14.3%), respectively. Hemodynamic support was provided for patients with hemodynamic instability; intra-aortic balloon pumping was used in nine patients (2.1%), and extracorporeal membrane oxygenation was used in three patients (0.7%) (Table 1).

3.3 | Successive rate of distal transradial access

The successive rates of DRA puncture on the same side in all cohorts were 94.3%, 89.6%, and 89.6% in the second, third, and fourth procedures, respectively (Supplemental table S1). After classification according to sex, the successive rates were 95.6%, 90.6%, and 90.6% in the male cohort, and 90.1%, 86.5%, and 86.5% in the female cohort, respectively (Figure 2). The successive rate in the female cohort tended to be lower than that in the male cohort, although the difference was not significant.

3.4 | Access site conversion

Access site conversion was observed in 30 of 419 patients (71.5%, 19 men). The reason for access site conversion was RAO detected by sonography or angiography in nine patients (2.1%), radial artery narrowing in 19 patients (4.5%), and puncture failure with patent DRA in two patients (0.5%) (Table 2).

Univariate analysis revealed that smaller height, lower weight, lower body surface area, left arm dTRA at the first attempt, ultrasound-guided puncture, and longer procedure time were significantly associated with access site conversion (Table 3). Multivariate analysis indicated that body surface area and procedure time at the first dTRA attempt were independent predictors of access site conversion (Table 4).

4 | DISCUSSION

The current study investigated the feasibility and safety of repeated dTRA use in the same arm. The second dTRA procedure was successfully performed in the same DRA in 94.3% of cases, and the subsequent successive rate in the third and fourth attempts was 89.6%. Access site conversion was attributed to RAO ($n = 9$), narrowing of the DRA ($n = 19$), and puncture failure ($n = 2$). The independent predictors for access site conversion were found to be a smaller body surface area and longer procedure time in the first procedure.

	Success (n = 389)	Convert (n = 30)	p value
Age (years)	71.8 ± 10.9	72.7 ± 10.0	0.661
Sex—male gender	299 (76.9%)	19 (63.3%)	0.119
Height (cm)	162.4 ± 9.1	158.6 ± 9.5	0.029
Weight (kg)	64.0 ± 13.6	57.4 ± 10.6	0.010
Body surface area (m ²)	1.68 ± 0.20	1.58 ± 0.18	0.008
Body mass index (kg/m ²)	24.1 ± 4.3	22.7 ± 3.1	0.086
Hemoglobin (g/dl)	13.6 ± 2.0	13.3 ± 2.3	0.386
Serum creatinine (mg/dl)	0.97 ± 0.37	0.90 ± 0.30	0.316
Diabetes mellitus	134 (34.4%)	10 (33.3%)	1.000
Hypertension	321 (82.5%)	23 (76.7%)	0.457
Dyslipidemia	299 (76.9%)	21 (70.0%)	0.379
Smoking history	251 (64.5%)	15 (50.0%)	0.119
Previous MI	70 (18.0%)	10 (33.3%)	0.052
Emergency	89 (22.9%)	8 (26.7%)	0.654
Acute coronary syndrome	91 (23.4%)	5 (16.7%)	0.503
Acute heart failure	17 (4.4%)	1 (3.3%)	1.000
Shock on arrival	4 (1.0%)	0 (0%)	1.000
Cardiac arrest	6 (1.5%)	0 (0%)	1.000
Use of IABP	9 (2.3%)	0 (0%)	1.000
Use of ECMO	3 (0.8%)	0 (0%)	1.000
LV ejection fraction (%)	58.5 ± 12.3	54.6 ± 15.4	0.103
Previous radial puncture	123 (31.6%)	10 (33.3%)	0.841
Dose of heparin (U/L)	5722 ± 2900	5700 ± 3261	0.968
Right dRA puncture	357 (91.8%)	23 (76.7%)	0.014
Left dRA puncture	32 (8.2%)	7 (23.3%)	
Ultrasound-guided puncture	169 (43.4%)	23 (76.7%)	<0.001
Sheath size ^a			
3-Fr	2 (0.5%)	0 (0%)	0.852
4-Fr	279 (71.7%)	22 (73.3%)	
5-Fr	53 (13.6%)	3 (10.0%)	
6-Fr	55 (14.1%)	5 (16.7%)	
Sheathless guide system	8 (2.1%)	0 (0%)	1.000
Procedure time (min)	48.3 ± 22.5	57.7 ± 26.2	0.030

Note: Values represent mean ± SD or number (%). A two-tailed *p*-value <0.05 was considered statistically significant.

^aRefer Table 1 for sheath sizes.

TABLE 3 Patients' background, procedural characteristics, and access site conversion

TABLE 4 Independent predictors of access site conversion on multivariate analysis

Factor	Odds ratio (95% CI)	p value
Body surface area (m ²)	0.08 (0.01–0.54)	0.010
Procedure time (min)	1.02 (1.00–1.03)	0.038
Sheath size (Fr)	0.85 (0.45–1.59)	0.61

A two-tailed *p*-value <0.05 was considered statistically significant. Abbreviation: CI, cutoff index.

Since the introduction of dTRA, this procedure was expected to have a lower incidence of bleeding complications because of the anatomical configuration of the DRA, which has a smaller diameter.

For the Japanese population, a previous study revealed that the vessel diameter of the DRA is 11%–15% smaller than that of the forearm radial artery.⁷ Thus, the smaller artery size is considered to be a possible advantage of dTRA in the context of hemorrhagic complications. Indeed, Kiemeneij reported a 0% major bleeding rate in 70 patients who underwent left dTRA.⁸

Conversely, a smaller artery size was of concern with regards to the patency of the radial artery. However, Kiemeneij reported in the same paper that the RAO rate associated with forearm radial artery access was 0%. This result is also concordant with a very early report by Kaledin et al., which showed that the incidence of RAO in dTRA was significantly lower than that in cTRA (2.2 vs. 4.2%, *p* = 0.011).⁵

Furthermore, a more recent systematic review reported that the incidence of RAO in patients with dTRA was 1.7%.³ Thus, the lower RAO rate in the dTRA suggests that repeated use of the dTRA is more promising than cTRA as an alternative access site for coronary catheterization. With regard to the successive rate of cTRA, an early study reported a lower successive rate of approximately 80% in men and 70% in women at the fourth attempt.⁴ In the same study with cTRA, the reason for dropout ($n = 62$) was attributed to narrowing or occlusion of the radial artery in 38 patients, failed puncture in 18 patients, severe spasm in previous TRA in four patients, and giant hematoma formation in two patients. In the current study, all dropout cases were examined by ultrasonography before or during the puncture attempt. Based on ultrasonographic findings, the reasons for dropout were categorized as vessel occlusion ($n = 9$), vessel narrowing ($n = 19$), and puncture failure ($n = 2$). Although direct comparison with the current study is difficult, the difference in the prevalence of puncture failure should be noted. This difference may be attributed to the high incidence of ultrasound-guided puncture in the current study. Both univariate and multivariate analyses revealed that access site conversion was associated with smaller height and weight, which indicates that small stature patients are considered to have a smaller radial artery, which is considered vulnerable to RAO. Conversely, the sheath size in the initial procedure was not associated with access site conversion. In daily practice with dTRA, the operator naturally tends to use a smaller sheath or sheathless guiding catheter system for smaller patients. In particular, the recent wide availability of the thin wall sheath introducer and sheathless guiding catheter system enables the reduction of the sheath artery ratio without jeopardizing therapeutic device selection. Therefore, sheath size per se may not have appeared to be a predictor of dropout.

This study had several limitations. First, this was a single-center, retrospective study, and the results may be biased by the operators' and institutional expertise. Second, the manner of hemostasis in dTRA is not commonly established, and consequently, the RAO rate of dTRA may vary between facilities. Third, this study did not perform a statistical comparison between dTRA and cTRA because this was a single-arm study. Therefore, the findings of this study are not necessarily applicable to every hospital performing percutaneous coronary intervention. Large-scale randomized studies are needed to evaluate the possible advantages of dTRA over cTRA.

5 | CONCLUSIONS

The successive rate of the dTRA in the same arm was maintained at 89.6%, even at the fourth attempt. The current data indicate that repeated dTRA is safe and feasible, and this approach may become a standard approach site in the future.

CONFLICT OF INTEREST

The authors report no financial relationships or conflicts of interest regarding the content.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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