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Research article

Comparison of radial artery occlusion between traditional radial access and distal radial access for coronary angiography and intervention: A prospective cohort study

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A R T I C L E I N F O

Keywords:
Coronary artery disease
Radial artery occlusion
Distal radial access

A B S T R A C T

Background: The radial approach is now recommended as the default strategy in diagnostic coronary angiography and percutaneous coronary intervention. Radial artery occlusion (RAO) is the most common complication that limits subsequent angiographic procedures through this access. Recently, distal radial access (DRA) has been recommended as an alternative access site. Despite lower RAO rates in DRA in some recent clinical trials, concerns remain regarding possible complications and limitations due to the small size of the distal radial artery.
Objective: The present study aimed to compare traditional radial access (TRA) and DRA concerning RAO in percutaneous coronary procedures.
Methods: In the present prospective cohort study, percutaneous coronary procedures were performed via DRA or TRA in 2 study groups. All consecutive participants underwent DRA from September 2021 to March 2022 and TRA from April 2022 to June 2022. Ultrasonography was performed preprocedurally in the DRA group, and patients with small distal artery diameters (<2 mm) were excluded. The same 6-Fr sheaths and standard air-filled compression devices were used in both groups. The primary endpoint was RAO in ultrasound sonography on the first post-procedural day, and the secondary endpoints were the success rate, access time, angiography time, radial artery spasms, and vascular access complications.

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Results: A total of 298 patients were assigned to the DRA group and 278 to the TRA group. The RAO rate was significantly higher in the TRA group than in the DRA group (10.1 % vs 0.9 %; $P =$ 0.0001; OR, 0.08, 95 % CI, 0.01–0.27). The success rate was significantly higher in the TRA group (96 % vs 90.2 %; $P = 0.009$). Access crossovers were done on 12 patients (4.0 %) in the TRA group and 24 patients (9.8 %) in the DRA group ($P < 0.001$). The mean access time was significantly lower in the TRA group than in the DRA group (1.9 min vs 2.9 min; $P < 0.001$). The mean angiography time did not significantly differ between the groups (10.2 min in the TRA group vs 9.9 min in the DRA group). The rate of radial artery spasms was not significantly different between the 2 groups (13.8 % in the TRA group vs 14.5 % in the DRA group). The rates of access site hematoma (12.4 % vs 2.3 %; $P < 0.001$) and bleeding (10.7 % vs 4.1; $P = 0.005$) were significantly higher in the TRA group.

Conclusions: DRA was safe and feasible with lower rates of RAO and access site complications than TRA. Thus, it could be used as an alternative approach in percutaneous coronary procedures. However, the trade-off for these advantages of DRA is an increase in cross-over rate, and a decrease in puncture success rate.

1. Introduction

The radial-first approach is now recommended as the default strategy in major international guidelines for diagnostic coronary angiography and percutaneous coronary intervention (PCI) [1,2] given its impact on vascular access complications and bleeding and, thus, survival benefits and patient convenience and satisfaction [3]. However, the risk of radial artery spasms, radial artery occlusion (RAO), disturbed access ergonomics, patient discomfort (due to the external rotation of the hand during access acquisition), and operator inconvenience (eg, bypass graft cannulation) are notable traditional radial access (TRA) limitations [4].

Distal radial access (DRA) in the anatomical snuff box or the dorsum of the hand has emerged in recent years as a promising alternative access site. Lower RAO and more convenient access acquisition (ie, the radial artery can be punctured in the hand's neutral posture) for both patient and operator are among the potential advantages of DRA. Nonetheless, the small distal radial artery caliber, the limited sheath size, the need for more instruments, and the longer learning curve are considered the disadvantages of DRA.

To better understand the efficacy and safety of DRA in current practice, we conducted a real-world cohort study on all-comers candidates for diagnostic coronary catheterization in a large academic cardiovascular tertiary center.

2. Methods

A prospective cohort with 2 phases was designed for the current study. For the first and second phases, DRA-first and TRA-first approaches were performed, respectively, on candidates for diagnostic catheterization at Rajaie Cardiovascular Medical and

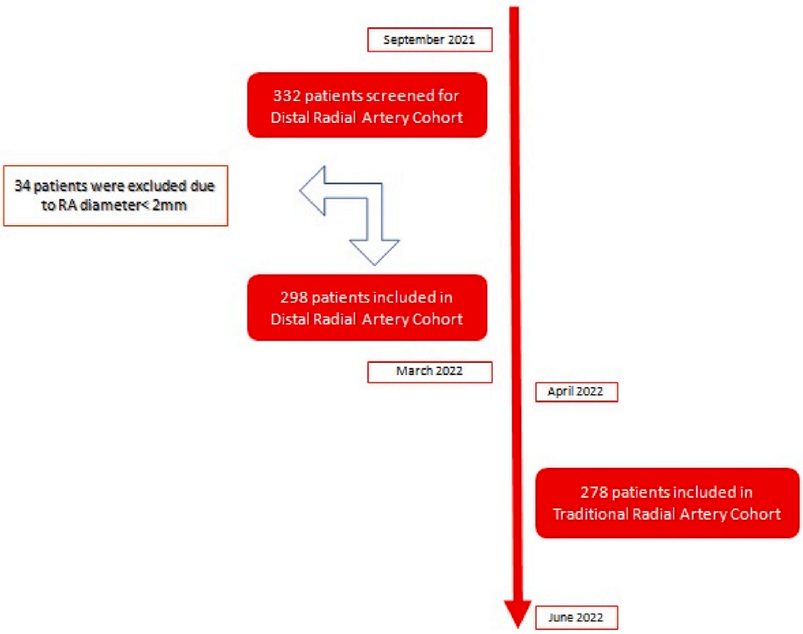

Fig. 1. Flowchart of study participants.

Research Center, Tehran, Iran. The 2 phases were scheduled to be performed consecutively (Fig. 1). The institutional ethics committee approved the study protocol (code: IR.IUMS.FMD.REC.1401.246), and the entire study population provided written informed consent.

2.1. Patients

The current study recruited patients older than 18 years who were candidates for diagnostic coronary catheterization. Patients with no radial artery palpable pulse, patients with trauma to or vascular procedures on the hand, candidates for primary PCI or bypass graft catheterization, and patients with bleeding diathesis (INR>1.8 platelet count <100000/dL), high bleeding risk patients, prior radial artery catheterization, patients with anemia (hemoglobin less than 13 in men and less than 12 in women) and patients with creatinine clearance less than 60 ml/min were excluded from the study. Demographic, clinical, and procedural data for each patient were gathered in a pre-specified case report sheet. All consecutive participants attending our center between September 2021 and March 2022 were allocated to the DRA group, and those recruited between April 2022 and June 2022 were allocated to the TRA group.

2.2. Procedures

In both phases, TRA and DRA were acquired by 2 experienced interventional cardiologists. The learning curve for distal radial puncture was completed for both of them. (more than 200 distal radial puncture before this study).

For coronary catheterization via DRA, the candidates were first scheduled for radial artery ultrasound and were only included if the radial artery diameter was above 2 mm. The distal radial artery was punctured at an entry angle of 30°–45°, with the skin in the anatomic snuff box. The TRA site was punctured at an entry angle of 30°–45°, with the skin 1–2 cm proximal to the styloid process of the radius bone for patients recruited during the second phase.

A 6-Fr guide sheath was used for all the patients in both study groups. All the patients received 100 μg of nitroglycerin via the sheath side to prevent arterial spasms. Additionally, 5000 units of unfractionated heparin were injected via an intravenous line for all the patients, and an adjusted bolus was administered if the patient was a candidate for PCI to achieve an activated clotting time of 250–300 s during the procedure [5].

Following the procedure, hemostasis was achieved with an air-filled compression device for both groups. The air volume of the device was adjusted to 2 mm^3 above the bleeding point in the DRA group and 3–5 mm^3 above the bleeding point in the TRA group to maintain hemostasis and radial artery patency. For patent hemostasis, plethysmography (pulse oximetry) was employed while the ulnar artery was compressed and arterial waves were monitored. Two hours after coronary angiography and 3 h following coronary angioplasty, the hemostatic compression device was removed completely after the periodic decrease in compression pressure. To simulate the real world, we followed the protocol of our center for decompressing compression devices while our nurses were unaware of patient enrollment in the study. In case of access site bleeding after compression device removal, a compressive bandage was employed to control bleeding.

2.3. Doppler ultrasound examination

During the first phase of the study, eligible patients were screened for DRA. During this phase, we screened all patients with radial artery ultrasonography and excluded patients with distal radial artery diameter less than 2 mm. During the second phase of the study, TRA group recruitment, no pre-procedural ultrasound was performed. All the patients in both phases underwent ultrasound examinations 12–24 h after the procedure for vascular access site complications, including hematoma, pseudoaneurysm, arteriovenous (AV) fistula, and RAO. The RAO was considered if no flow signal could be detected. All the ultrasound examinations were performed by a single radiologist operator.

2.4. Study outcomes

The primary endpoint of the study was RAO, and the secondary endpoints consisted of the success rate, access time, angiography time, radial artery spasms, and vascular access complications (eg, hematoma, pseudoaneurysm, and AV fistula), all of which were confirmed by Doppler ultrasound. All the patients were followed up until hospital discharge. Access time was defined as the time between local anesthesia and the end of sheath insertion. Diagnostic catheterization time was considered to be the period between sheath insertion and the end of diagnostic angiography on the left and right coronary arteries. Procedural access success was defined as successful cannulation and coronary angiography or angioplasty via the access site without crossovers to other access sites. Radial artery spasms were defined as any pain or difficulty in catheter passage during diagnostic angiography. Radial artery Doppler sonography was performed for all the patients in both groups within 24 h after the procedure to evaluate possible complications.

For patients who underwent PCI, simple or complex PCI procedures were documented. A complex PCI procedure was defined as a PCI procedure on the left main artery, multivessel lesions, bifurcation lesions, coronary total occlusion (CTO), and American Heart Association/American College of Cardiology type C coronary lesions [5].

2.5. Statistical analysis

The fitness of interval data to the normal distribution was assessed using the 1-sample Kolmogorov–Smirnov test. Data were described as counts (percentages) for qualitative variables and medians (interquartile ranges) for numerical variables. Between-group comparisons were performed using the Pearson χ^2 test for categorical data and the Mann–Whitney *U* test for interval data. A *P* value of less than 0.05 was considered statistically significant. Univariate and multiple logistic regression models were employed to predict the primary outcome. The statistical analyses were carried out with IBM SPSS Statistics 22 for Windows (IBM Inc, Armonk, NY).

3. Results

From September 2021, 332 patients were assigned to the DRA group. Of this total, 34 patients (10.2 %) were excluded due to small distal radial artery diameters (<2 mm) in Doppler sonography. Subsequently, 278 patients were assigned to the TRA group (Fig. 1). The baseline characteristics of the patients in both study groups are presented in Table 1 in detail.

Overall, the mean age of the patients was 61 years. Men accounted for 66 % of the study population. Diabetes mellitus was reported in 34 % and arterial hypertension in 53 %. Except for a family history of premature coronary artery disease and hyperlipidemia, the other baseline characteristics were not significantly different between the TRA and DRA groups.

More patients in the TRA group underwent PCI (56.8 % vs 40.4 %; $P < 0.001$), whereas more complex lesion PCI procedures were performed in the DRA group (16.8 % vs 13.8 %; $P < 0.001$).

3.1. *Primary outcome*

The RAO rate was significantly higher in the TRA group than in the DRA group (10.1 % vs 0.9 %; P = 0.0001; OR, 0.082; 95 % CI, 0.08 (0.0153–0.2736)).

3.2. *Secondary outcomes*

The success rate was significantly higher in the TRA group than in the DRA group (96 % vs 90.2 %; $P = 0.009$). Access crossovers were performed in 12 patients (4.0 %) in the TRA group and 24 patients (9.8 %) in the DRA group ($P < 0.001$). The crossovers in the TRA group in 2 patients (16.7 %) were to the contralateral TRA and in 10 patients (83.3 %) to femoral access. All the crossovers in the DRA group occurred to the same hand TRA, and there was no need to crossover to the femoral artery.

The mean access time was significantly lower in the TRA group than in the DRA group (1.9 min vs 2.9 min; $P < 0.001$). The mean angiography time was not significantly different between the TRA and DRA groups (10.2 min vs 9.9 min). The rate of radial artery spasms did not significantly differ between the TRA and DRA groups (13.8 % vs 14.5 %). The rates of access site hematoma and bleeding were significantly higher in the TRA group than in the DRA group (hematoma: 12.4 % vs 2.3 %; $P < 0.001$ and bleeding: 10.7 % vs 4.1 %; $P = 0.005$). No case of pseudoaneurysm or compartment syndrome was reported in each group.

The primary and secondary outcomes are shown in Table 2 in detail.

As demonstrated in Table 3, the multiple logistic regression model for prediction of RAO demonstrated that DRA was an in dependent predictor of RAO when adjusted for age, sex, diabetes mellitus, current smoking, and complexity of PCI (OR [95%CI]: 0.08 [0.02, 0.35], p-value: 0.001).

4. Discussion

In the current large-scale real-world study on 542 participants, we compared RAO occurrence, procedural success, feasibility, and complications between conventional TRA and selected cases of DRA with a distal radial artery size above 2 mm in candidates for coronary diagnostic and therapeutic catheterization. It has been shown that not only is TRA more successful and rapid than DRA, but also it is associated with significantly fewer intraprocedural crossovers. Still, the principal complications of PCI, such as access site hematoma, bleeding, and RAO, were significantly higher in our TRA group than in our DRA group.

More interventional cardiologists have shown an interest in left DRA since Kiemenij [6] advocated it in 2017 [7,8]. Currently, the

Table 1
Baseline characteristics of the study population[a].

Characteristics	TRA Group (n = 298)	DRA Group (n = 278)	*P* value	Total Population (N = 576)
Sex (%) male	203 (68.1)	180 (64.7)	0.43	383 (66.5)
female	95 (31.9)	98 (35.3)		193 (33.5)
Age, y	61 (55–68)	61 (53–69)	0.87	61 (54–65)
BMI	26.7 (24.6–28.9)	27.1 (24.6–31)	0.08	26.8 (24.6–29.7)
Hypertension (%)	148 (49.7)	161 (57.9)	0.05	309 (53.6)
Diabetes mellitus (%)	101 (33.9)	95 (34.2)	0.94	196 (34)
Hyperlipidemia (%)	80 (26.8)	100 (36)	0.02	180 (31.3)
Cigarette smoking (%)	83 (27.9)	64 (23)	0.21	147 (25.5)
Family history of CAD (%)	40 (13.4)	62 (22.3)	0.006	102 (17.7)
PCI	Total: 169 (56.8 %)	Total: 89 (40.4 %)	<0.001	Total: 258 (44.79 %)
	Simple: 128 (43 %)	Simple: 52 (23.6 %)	0.004	Simple: 180 (34.7 %)
	Complex: 41 (13.8 %)	Complex: 37 (16.8 %)		Complex: 78 (15.1 %)

BMI, body mass index; CAD, coronary artery disease; DRA, distal radial access; PCI, percutaneous coronary intervention; TRA, traditional radial access
Data other than frequencies are presented as medians (interquartile ranges).

Table 2
Primary and secondary outcomes in the study groups.

	TRA	DRA	*P* value	Odds ratio (95 % CI)	Total
Primary Outcome					
RAO (%)	30 (10.1)	2 (0.9)	<0.001	0.08 (0.015–0.274)	32 (6.2 %)
Secondary Outcomes					
Radial spasms	41 (13.8 %)	32 (14.5 %)	0.90	1.07 (0.648–1.758)	73 (14.1 %)
Access hematoma	37 (12.4 %)	5 (2.3 %)	<0.001	0.16 (0.632–0.425)	42 (8.1 %)
Bleeding	32 (10.7 %)	9 (4.1 %)	0.008	0.35 (0.166–0.759)	41 (7.9 %)
Pseudoaneurysm	0	0			0
AVF	0	0			0
Compartment syndrome	0	0			0
Procedural Success	286 (96 %)	220 (90.2 %)	0.009	2.6 (1.272–5.314)	506 (93.4 %)
Access crossover	Contralateral radial access: 2 (0.67 %) Femoral access: 10 (3.35 %) Total: 12 (4.02 %)	Ipsilateral radial access: 24 (9.8 %)	<0.001		Ipsilateral radial access: 24 (66.7 %) Other-side Radial: 2 (5.6 %) Femoral: 10 (27.8) Total: 36 (100 %)
Access acquisition time, min	1.9 (1–2)	2.9 (1.25–3.75)	<0.001		2.3 (1–3)
Procedural duration, min	10.2 (7–12)	9.9 (7–11)	0.35		10 (7–12)

DRA, distal radial access; RAO, radial artery occlusion; AVF, arteriovenous fistula; TRA, traditional radial access.

Table 3
Unlivariate and multivariable logistic regression model for prediction of RAO.

Variable	Univariate model			Multivariate Model		
	β (SE)	OR [95 % CI]	p-value	β (SE)	Adjusted OR [95 % CI]	Adjusted p-value
Sex	−0.31 (0.42)	0.73 [0.32, 1.67]	0.458	−0.44 (0.45)	0.64 [0.26, 1.56]	0.330
Cigarette smoking	−0.28 (0.44)	0.76 [0.32, 1.80]	0.530	−0.61 (0.48)	0.54 [0.21, 1.38]	0.202
Diabetes Mellitus	−0.25 (0.40)	0.77 [0.35, 1.71]	0.530	−0.36 (0.43)	0.70 [0.30, 1.61]	0.397
Age ≥60	−0.23 (0.38)	0.79 [0.37, 1.69]	0.550	−0.33 (0.40)	0.72 [0.33, 1.57]	0.403
PCI	0.43 (0.24)	1.53 [0.96, 2.44]	0.072	0.40 (0.26)	1.50 [0.90, 2.49]	0.121
DRA	−2.50 (0.74)	0.08 [0.02, 0.35]	**0.001***	−2.51 (0.74)	0.08 [0.02, 0.35]	**0.001***

CI: **Confidence Interval;** DRA: **Dista Radial Access;** OR: **Odds Ratio;** PCI: **Percutaneous Coronary Intervention**

success rates of DRA punctures and procedures range from 70 % to 100 % [7]. In 3 recent randomized controlled trials, the access site crossover rate was higher in DRA, with rates of 8.4 %, 13.3 %, and 21.8 % in the DISCO RADIAL, DAPRAO, and ANGIE trials, respectively [9–11].

In the present study, the number of punctures was 1–3 times, implying that the safety and efficacy of DRA are comparable to those of the conventional strategy. A prevalent misconception is that DRA proficiency is hard to achieve, and data are insufficient to recommend moving from standard radial to DRA. On the other hand, the superficial position of the distal radial artery may support speedier and more successful hemostasis. Furthermore, enhanced operator experience and the increased use of ultrasound-guided punctures elevate the rate of successful access site punctures and lower crossovers and even access site complications [12].

Therefore, the following factors may explain why the procedural success rate in DRA was lower than that in TRA in the present investigation.

1) The diameter of the radial artery in the access site is smaller than that in the wrist, rendering sheath insertion after successful punctures challenging.
2) The tortuosity of the distal radial artery is common, which easily leads to the failure of guide wire and sheath insertion into the radial artery.

Ultrasound-guided access to the distal radial artery at the anatomic snuff box was recently introduced by Hadjivassiliou et al. [13] They emphasized that ultrasound guidance has several advantages including determination of accurate location for puncture, assessment of vessel size, potential tortuosity, calcification, and also puncture-related complications such as arterial spasm, hematoma, arterial dissection, and RAO [13].

As expected, access time was longer in our DRA group. Chiming in with our findings, Valgimigli et al. [11] reported a mean access time of 120 s in DRA and 75 s in TRA. Nonetheless, angiography time was not affected significantly by these 2 radial access sites.

Acute arterial occlusion is assumed to be a thrombotic event occurring in the context of chronic occlusive changes. During TRA, sheath insertion and instrumentation cause endothelial injury, exposing the connective tissue to thrombogenic events. Furthermore, while attempts are made to attain hemostasis, blood stasis provides a nidus for thrombus development [14]. Two meta-analyses estimated the incidence of RAO in TRA at between 5.6 % and 7.7 % [15,16]. Recently, the ANGIE trial reported a significantly higher RAO rate in proximal radial access than in DRA (7.9 % vs 3.7 %) [11]. The DAPRAO trial also showed a lower RAO rate in DRA than in proximal radial access (1 % vs 8.4 %) [10]. Our study had comparable results insofar as RAO incidence in the DRA group was less than one-tenth that in the TRA group, and the rate of RAO in DRA was below 1 %. In the recent DISCO RADIAL trial, the RAO rate was 3 times less in DRA than in TRA; however, the difference failed to constitute statistical significance owing to the very low incidence of RAO (0.9 % in TRA and 0.3 % in DRA). The low rate of RAO incidence was due to the strict study protocol concerning anti-coagulation, patent hemostasis, minimal pressure strategies, and the use of 6-Fr sheaths with smaller outer diameters than routine sheaths [17]. Blinding of caring personnel was not possible, given the location of air-filled compression devices differed for DRA and TRA (Supplementary Fig. 1). The higher rate of RAO detected in the TRA group in our study might be attributable, at least in part, to the fact that the caring personnel knew which patients were allocated to the DRA group and might have provided more attentive care to these patients. In addition, since we performed decompression and pressure hemostatic device removal according to routine ward protocols, our information can be considered real practice data. The very low incidence of RAO in DRA in our investigation may be due to the exclusion of small distal radial arteries by Doppler sonography. Various RAO rates in DRA have been reported so far. In line with our findings, clinical studies have shown very low RAO rates, with a significant difference from the TRA method. In a clinical trial conducted by Eid-Lidt et al. [18], TRA had an RAO rate exceeding 10 times that of DRA. Comparable findings were reported in large-scale randomized controlled trials by Tsigkas et al. [20] and Ziakas et al. [19,20] Previous randomized controlled trials comparing RAO between TRA and DRA have reported RAO rates of 2.5 %–8.4 % in TRA and 0–5 % in DRA [21–25].

Another novel benefit of DRA is retrograde recanalization of the radial artery occlusion via a distal radial artery. In a single center study, 14 of 15 patients with RAO were recanalized successfully from DRA and the procedure was done [26].

The strong anastomotic network connecting the deep and superficial arterial branches in the wrist and hand region preserves forearm radial artery blood flow and prevents localized edema. Moreover, the related forearm radial artery compression is the most likely pathophysiological rationale for the observed drop in the forearm RAO rate in DRA [27]. Consequently, the issue of radial artery blockage at the forearm appears to be resolved by DRA in conjunction with ultrasonography, along with improved outpatient PCI outcomes, augmented patient and operator comfort, and shortened compression time [28].

In our study, the incidence rate of radial artery spasms was similar in both groups; nonetheless, it was much higher than the rate in previous studies [18,19,21,22,24]. Our more rigorous definition of spasms may be the reason for this high spasm incidence. In the DISCO RADIAL trial, radial artery spasms occurred more frequently in DRA than in TRA (5.4 % vs 2.7 %) [17].

The complications of DRA, including hemorrhage, hematoma, pseudoaneurysm, and AV fistula, have been reported in previous studies [29,30]. The complications could be associated with the anatomical snuff box, featuring a bone basement surrounded by tendons. We had no cases of pseudoaneurysm and AV fistula in either study group, but the rates of bleeding and hematoma were considerably lower in the DRA group than in the TRA group. The DAPRAO and ANGIE trials reported similar bleeding and hematoma rates in their 2 study groups [10,11]. Recently, Oliveira et al. [31], in a report from the DISTRACTION registry, showed no moderate or severe hematoma (type $\geq$2, according to the EASY classification) in 3683 patients with coronary interventions via DRA. The low incidence of bleeding complications in DRA compared with TRA in our study may be due to the selection of patients with larger distal radial arteries by Doppler sonography and the ruling out of patients with the potential of vessel wall injury due to small artery diameters. The use of air-filled compression devices for hemostasis with a similar protocol to TRA for all the patients in the DRA group may have played a role in the lower incidence of bleeding complications in the current study. On the other hand, the bony structure of the snuff box and the small free space for blood pooling may decrease the chance of bleeding complications in DRA.

Finally, a significant issue is that while other trials have excluded CTO PCI, [6] we performed CTO and complex lesion PCI through DRA with no added difficulties. The number of complex lesion PCI procedures was even higher in our DRA group, showing that DRA is not a limitation for complex interventions. Recent study has stated that intervention via radial access has similar success rate in CTO PCI with femoral access. The procedural success rate of CTO PCI and its periprocedural and long-term adverse events are reported to be comparable between DRA and TRA [32,33]. It has been suggested that implication of distal left radial artery access might alleviate some of the technical challenges of CTO PCI especially in morbidly obese patients [34].

4.1. Limitations

Patients assignment into the two study groups was not randomized, which is the main limitation of the current investigation, potentially creating imbalancy between baseline characteristics of the two study groups and selection bias. To reduce discrepancies and omit the role of potential confounding factors, a multivariable analysis was performed, in which DRA was still a protective predictor for RAO. A single-center design is another salient drawback of our study and sample size was set according to the available resources. Another limitation was the time of imaging follow up; RAO was just comp.ared between the two study groups at 12–24 h after the procedure. Nontheless, available evidence with 30-day imaging follow up, suggests RAO occurred in in nearly all patients during the first 24 h postprocedurally [35]. Another weakness of note is the exclusion of primary PCI and post-coronary CABG patients. Of note, DRA was performed successfully in post-CABG patients in recent studies. Finally, only patients assigned to the DRA group proceeded to pre-procedural ultrasound, which might potentially create a selection bias between the two study groups.

5. Conclusion

We strongly recommend DRA over TRA in patients whose distal radial diameters exceed 2 mm. However, the trade-off for these advantages of DRA included a reduced puncture success rate and an increased cross-over rate when compared to TRA [36].

CRediT authorship contribution statement

Ali Zahedmehr: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Amir Dousti:** Methodology, Investigation, Formal analysis, Data curation. **Mohammad Javad Alemzadeh-Ansari:** Resources, Methodology, Data curation, Conceptualization. **Abdullah Gharibzadeh:** Investigation, Data curation. **Mehdi Sheibani:** Data curation. **Mohammadhossein Mozafarybazargany:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Ata Firouzi:** Data curation. **Seifollah Abdi:** Data curation. **Zahra Hosseini:** Investigation, Data curation. **Mohammadreza Baay:** Data curation. **Armin Elahifar:** Investigation, Data curation, Conceptualization. **Mohsen Maadani:** Data curation. **Farshad Shakerian:** Data curation. **Reza Kiani:** Data curation. **Hossein Toreyhi:** Data curation. **Jamal Moosavi:** Data curation. **Bahram Mohebbi:** Data curation. **Amir Abdi:** Data curation. **Ehsan Khalilipur:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Parham Sadeghipour:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Data and code availability

Data will be made available on request.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:The corresponding author, Dr. Parham Sadeghipour, serves as an associate editor in Heliyon, Cardiovascular Section. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e39451.

References

[1] F.-J. Neumann, et al., ESC/EACTS guidelines on myocardial revascularization. The task force on myocardial revascularization of the European Society of Cardiology (ESC) and European Association for Cardio-Thoracic Surgery (EACTS), Giorn. Ital. Cardiol. 20 (7–8 Suppl 1) (2018) 1S–61S, 2019.
[2] J.S. Lawton, et al., ACC/AHA/SCAI guideline for coronary artery revascularization, J. Am. Coll. Cardiol. 79 (2) (2021) e21–e129, 2022.
[3] P. Lee, et al., The cost-effectiveness of radial access percutaneous coronary intervention: a propensity-score matched analysis of Victorian data, Clin. Cardiol. 45 (4) (2022) 435–446.
[4] R.E. Davies, I.C. Gilchrist, Back hand approach to radial access: the snuff box approach, Cardiovasc. Revascularization Med. 19 (3) (2018) 324–326.
[5] P. Libby, et al., Braunwald's Heart Disease-E-Book: A Textbook of Cardiovascular Medicine, Elsevier Health Sciences, 2021.
[6] F. Kiemeneij, Left distal transradial access in the anatomical snuffbox for coronary angiography (ldTRA) and interventions (ldTRI), EuroIntervention 13 (7) (2017) 851–857.
[7] G. Cai, et al., Distal transradial access: a review of the feasibility and safety in cardiovascular angiography and intervention, BMC Cardiovasc. Disord. 20 (1) (2020) 356.
[8] A. Aminian, et al., Distal versus conventional radial access for coronary angiography and intervention: design and rationale of DISCO RADIAL study, Am. Heart J. 244 (2022) 19–30.
[9] A. Aminian, et al., Distal versus conventional radial access for coronary angiography and intervention, JACC Cardiovasc. Interv. 15 (12) (2022) 1191–1201.
[10] I. Bernat, Distal radial approach: the next promising step in an even more minimally invasive strategy, American College of Cardiology Foundation Washington DC (2021) 386–387.
[11] M. Valgimigli, A. Landi, Distal transradial access for coronary procedures: old certainties, novel challenges, and future horizons, American College of Cardiology Foundation Washington DC (2022) 33–38.
[12] J.W. Roh, et al., The learning curve of the distal radial access for coronary intervention, Sci. Rep. 11 (1) (2021) 13217.
[13] A. Hadjivassiliou, et al., Ultrasound-guided access to the distal radial artery at the anatomical snuffbox for catheter-based vascular interventions: a technical guide, Eurointervention: Journal of Europcr in Collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology 16 (16) (2021) 1342–1348.

[14] S. Saito, et al., Influence of the ratio between radial artery inner diameter and sheath outer diameter on radial artery flow after transradial coronary intervention, Catheter Cardiovasc Interv 46 (2) (1999) 173–178.
[15] M. Rashid, et al., Radial artery occlusion after transradial interventions: a systematic review and meta-analysis, J. Am. Heart Assoc. 5 (1) (2016).
[16] G. Hahalis, et al., Radial artery and ulnar artery occlusions following coronary procedures and the impact of anticoagulation: ARTEMIS (radial and ulnar ARTE ry occlusion M eta-analys IS) systematic review and meta-analysis, J. Am. Heart Assoc. 6 (8) (2017).
[17] A. Aminian, et al., Distal versus conventional radial access for coronary angiography and intervention (DISCO RADIAL), JACC Cardiovasc. Interv. (2022) 1191–1201.
[18] G. Eid-Lidt, et al., Distal radial artery approach to prevent radial artery occlusion trial, Cardiovascular Interventions 14 (4) (2021) 378–385.
[19] G. Tsigkas, et al., Distal or traditional transradial access site for coronary procedures: a single-center, randomized study, Cardiovascular Interventions 15 (1) (2022) 22–32.
[20] A. Ziakas, et al., Right arm distal transradial (snuffbox) access for coronary catheterization: initial experience, Hellenic J. Cardiol. 61 (2) (2020) 106–109.
[21] M. Koutouzis, et al., Distal versus traditional radial approach for coronary angiography, Cardiovasc. Revascularization Med. 20 (8) (2019) 678–680.
[22] A.K. Sharma, et al., A comparative assessment of Dorsal radial artery access versus classical radial artery access for percutaneous coronary angiography-a randomized control trial (DORA trial), Indian Heart J. 72 (5) (2020) 435–441.
[23] H. Lu, D. Wu, X. Chen, Comparison of distal transradial access in anatomic snuffbox versus transradial access for coronary angiography, in: The Heart Surgery Forum, 2020.
[24] H. Wang, et al., A comparison of the clinical effects and safety between the distal radial artery and the classic radial artery approaches in percutaneous coronary intervention, Ann. Palliat. Med. (2020) 2568574, 2562574.
[25] Y. Lin, et al., Feasibility and safety of the distal transradial artery for coronary diagnostic or interventional catheterization, J. Intervent. Cardiol. (2020) 2020.
[26] G. Shi, et al., Retrograde recanalization of occluded radial artery: a single-centre experience and literature review, J. Endovasc. Ther. 29 (5) (2022) 755–762.
[27] G. Tsigkas, et al., Distal or traditional transradial access site for coronary procedures: a single-center, randomized study, JACC Cardiovasc. Interv. 15 (1) (2022) 22–32.
[28] A. Achim, et al., Distal radial artery access for coronary and peripheral procedures: a multicenter experience, J. Clin. Med. 10 (24) (2021).
[29] J.W. Lee, et al., Real-world experience of the left distal transradial approach for coronary angiography and percutaneous coronary intervention: a prospective observational study (LeDRA), EuroIntervention 14 (9) (2018) e995–e1003.
[30] K.M. Al-Azizi, et al., The left distal transradial artery access for coronary angiography and intervention: a us experience, Cardiovasc Revasc Med 20 (9) (2019) 786–789.
[31] M.D. Oliveira, E.C. Navarro, A. Caixeta, Distal transradial access for coronary procedures: a prospective cohort of 3,683 all-comers patients from the DISTRACTION registry, Cardiovasc. Diagn. Ther. 12 (2) (2022) 208.
[32] A. Achim, et al., Switching from proximal to distal radial artery access for coronary chronic total occlusion recanalization, Frontiers in Cardiovascular Medicine 9 (2022).
[33] E. Poletti, et al., Alternative (transulnar or distal radial) arterial access for chronic total occlusion percutaneous coronary intervention (subanalysis from the minimalistic hybrid approach algorithm registry), Am. J. Cardiol. 200 (2023) 57–65.
[34] T.B. DeSa, et al., The evolving role of transradial access in chronic total occlusion percutaneous coronary intervention, Am. J. Cardiol. 192 (2023) 258–260.
[35] G. Eid-Lidt, et al., Distal radial artery approach to prevent radial artery occlusion trial, JACC Cardiovasc. Interv. 14 (4) (2021) 378–385.
[36] M.D.P. Oliveira, E.C. Navarro, A. Caixeta, Distal transradial access for post-CABG coronary and surgical grafts angiography and interventions, Indian Heart J. 73 (4) (2021) 440–445.