CLINICAL STUDY

Transradial Approach for Noncoronary Interventions: A Single-Center Review of Safety and Feasibility in the First 1,500 Cases

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ABSTRACT

Purpose: To review safety and feasibility in a single center using transradial access (TRA) for noncoronary interventions.

Materials and Methods: Retrospective analysis was performed of 946 patients evaluated for 1,531 consecutive TRA procedures from April 2012 to July 2015. Exclusion criteria included sheath > 6 F, Barbeau D waveform, radial artery (RA) diameter < 2 mm on ultrasound, history of severe aortic tortuosity or RA occlusion, and dialysis. TRA was attempted in 936 patients (62% men; median age, 62.4 y) who underwent 1,512 consecutive procedures (chemoembolization [n = 485], yttrium-90 mapping [n = 391] and infusion [n = 293], renal/visceral intervention [n = 172], uterine artery embolization [n = 116], peripheral intervention [n = 43], endoleak repair [n = 10], and other [n = 2]). Patients were evaluated for complications during follow-up at ~30 days.

Results: Technical success was 98.2% (1,485/1,512). Major complications (0.13%) included pseudoaneurysm (n = 1) and seizure (n = 1). Minor complications (2.38%) included hematoma/bleeding (n = 13), RA occlusion (n = 11), arm pain (n = 6), and RA spasm (n = 6). Univariate analysis demonstrated a lower rate of adverse events in African American patients (hazard ratio [HR], 0.25; 95% confidence interval [CI], 0.07–0.86; $P = .027$). Twenty-seven cases (1.8%) required crossover to transfemoral access (TFA). Crossover rates were higher in female patients ($P = .0055$), height < 1.7 m ($P = .024$), renal/visceral interventions ($P = .0003$), and endoleak interventions ($P = .0357$). Multivariate analysis demonstrated intervention type to be the only significant predictor of TFA crossover (renal/visceral [HR, 4.48; 95% CI, 1.84–10.9; $P = .001$]; endoleak repair [HR, 9.54; 95% CI, 1.09–83.8; $P = .042$]).

Conclusions: TRA was safe and well tolerated in a heterogeneous patient population across a range of peripheral vascular interventions.

ABBREVIATIONS

RA = radial artery, RAO = radial artery occlusion, TFA = transfemoral access, TRA = transradial access

Numerous prospective randomized trials have been published in the last decade examining the safety and feasibility of transradial access (TRA) as an alternative to transfemoral access (TFA). Published in 2012, the RIFLE study by Romagnoli et al (1) demonstrated a 60% decrease in access site–related bleeding for TRA compared with TFA (2.6% vs 6.8%, $P = .002$) and a 17.3% reduction in net adverse clinical events (13.6% vs 21%, $P = .003$) in > 1,000 patients undergoing percutaneous coronary intervention (PCI). Overall length of hospital stay was also found to be reduced in patients with TRA (5 d vs 6 d, $P = .008$). Similar reductions in overall access site–related complications were demonstrated in larger prospective studies, including the 2012 RIVAL study by Mehta et al (2) and most recently the

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2015 MATRIX study by Valgimigli et al (3), which recommended that TRA should be the "default approach in patients with an acute coronary syndrome undergoing invasive management."

Since 2007, interventions using TRA in the United Kingdom have grown 25% per year, accounting for > 65% of all PCIs in 2012 (4). In 2013, approximately one in every six PCIs in the United States was performed using TRA (5). TRA has also been found to be significantly more cost-effective (6) than TFA, and patient preference for TRA has been documented (7). Despite this shift in access site preference among interventional cardiologists, TFA remains the predominant access site choice for peripheral and visceral interventions. Literature examining the feasibility of TRA for noncoronary interventions is relatively sparse, although its safety and feasibility have been described for uterine artery embolization (8), renal artery intervention (9), and transarterial chemoembolization (10). In a 2003 study by Shiozawa et al (10), overall access site complications were found to be significantly less in TRA versus TFA in treating hepatocellular carcinoma via transarterial chemoembolization (4.5% vs 12.7%), while maintaining comparable therapeutic efficacy. To date, the study by Shiozawa et al (10) has been the only study formally comparing the two access sites in a noncoronary procedure. Given the published benefits of TRA during PCI, we sought to investigate the safety and feasibility of TRA for noncoronary vascular interventions.

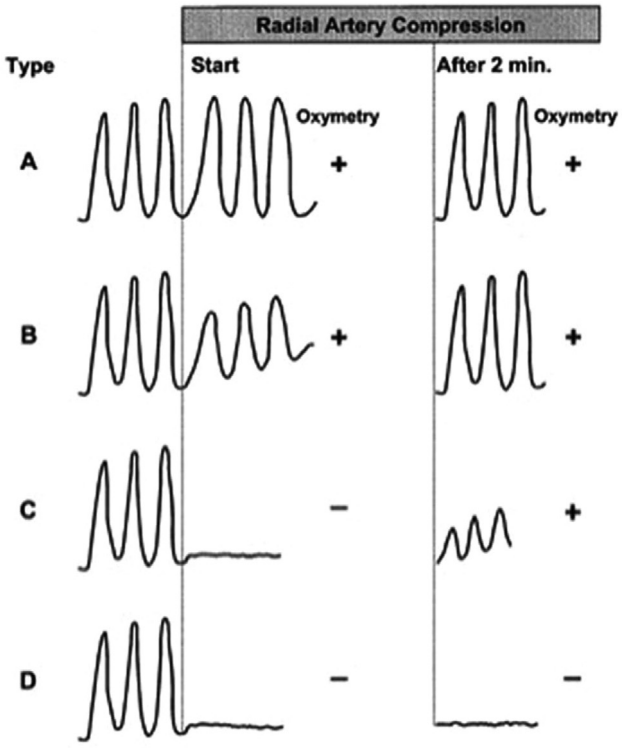
MATERIALS AND METHODS

Study Design and Exclusion Criteria

This single-center study was compliant with the Health Insurance Portability and Accountability Act and approved by the local institutional review board. A retrospective analysis was performed of 946 patients evaluated for 1,531 consecutive TRA procedures from April 2012 to July 2015. During this period, specific procedural data including sheath size, technical success, and complications were collected in a prospective manner for 1,512 consecutive TRA procedures in 936 patients who qualified for TRA.

Patients were initially given the option of TRA based on operator preference and experience with the TRA procedure type. Patients who consented to TRA were verified to have ulnar–palmar arch patency using a technique initially described by Barbeau et al (11). Patients displaying Barbeau waveform D (Fig 1), indicating inadequate ulnar–palmar arch patency, were excluded from TRA. Patients were also screened for additional TRA exclusion criteria, including sheath requirements > 6 F, radial artery (RA) diameter < 2 mm on ultrasound, prior history of severe vascular tortuosity or radial artery occlusion (RAO), or need for dialysis.

Patient demographic data, height, weight, and body mass index at the time of the procedure were obtained retrospectively searching the Epic electronic medical record system (Epic, Verona, Wisconsin) and the Mount Sinai Data Warehouse. Patient demographics and baseline characteristics before the procedure are presented in Tables 1 and 2.



Drawing representing the 4 types of ulnopalmar arch patency findings with PL and OX, as recorded with the finger clamp applied on the thumb.

Figure 1. Barbeau classification of pulse waveform responses to compression of the RA. (Reprinted with permission from Barbeau GR, Arsenault F, Dugas L, Simard S, Lariviere MM. Evaluation of the ulnopalmar arterial arches with pulse oximetry and plethysmography: comparison with the Allen's test in 1010 patients. Am Heart J 2004; 147:489–493 [11].)

Table 1. Patient Demographics (n = 936)

Characteristic	Value
Age (y)	62.4 (52.6–70.2)
Sex	
Male	580 (62.0)
Female	356 (38.0)
Ethnicity	
White	346 (37.0)
African American	208 (22.2)
Hispanic	163 (17.4)
Asian	101 (10.8)
Other	118 (12.6)

Note–Values presented as number (%) and median (interquartile range) as appropriate.

Table 2. Procedure Characteristics (n = 1,512)

Characteristic	Value
Age (y)	63.7 (56.3–70.2)
Sex	
Male	1,011 (66.9)
Female	501 (33.1)
Ethnicity	
White	570 (37.7)
African American	330 (21.8)
Hispanic	288 (19.0)
Asian	155 (10.3)
Other	169 (11.2)
Intervention	
Transarterial chemoembolization	485 (32.1)
RE mapping	391 (25.9)
RE treatment	293 (19.4)
Renal/visceral	172 (11.4)
UFE	116 (7.7)
Peripheral	43 (2.8)
Endoleak repair	10 (0.7)
Other	2 (0.1)
Prior left TRA	
Naïve	936 (61.9)
1	353 (23.3)
2	124 (8.2)
3	62 (6.4)
4	24 (1.6)
≥ 5	13 (0.9)
Sheath size (F)	
4	144 (9.5)
5	1,260 (83.3)
6	108 (7.1)
Weight (kg)*	76.2 (66.2–88.5)
Height (m)*	1.68 (1.63–1.75)
BMI (kg/m^2)*	
≤ 35	1,345 (15.3–34.98)
> 35	118 (35.02–66.6)

Note–Values presented as number (%) and median (interquartile range) as appropriate.
BMI = body mass index; RE = radioembolization; TRA = transradial access; UFE = uterine fibroid embolization.
*Denotes missing data (weight, n = 47; height, n = 49; BMI, = 49).

TRA Technique

A standard RA access technique, which was previously described in detail by Fischman et al (12), was used for all procedures. Diagnostic catheter lengths used for TRA were 100–150 cm, and standard length microcatheters 130–150 cm were used as needed. Procedure benefits and risks were discussed with patients before informed consent was obtained, including specifically the risks of crossing the left vertebral artery versus iliac artery manipulation.

After the procedure, all wires and catheters were removed. A TR Band (Terumo Interventional Systems, Somerset, New Jersey) was placed on the left wrist over the arteriotomy site. To minimize risk of RAO after the procedure, nonocclusive "patent hemostasis" was subsequently maintained for 60–90 minutes (13). Arterial hemostasis and pulse were reconfirmed as the band was incrementally deflated and removed. Repeat evaluation of the access site and radial pulse was performed for all patients before discharge and during the follow-up outpatient office visit at approximately 30 days.

Technical Success and Complications

Technical success was defined as successful RA access and completion of the intended procedure without crossover to an auxiliary access site. The inability to cannulate any vessel previously designated as a primary target for therapeutic intervention was also deemed a technical failure. In procedures requiring embolization or stent placement, nontarget release of embolization agents or stent deployment were also considered technical failures.

Classification of complications was based on the quality improvement guidelines published by the Society of Interventional Radiology (SIR) (14). Neurologic complications were documented according to the Common Terminology Criteria for Adverse Events version 4.03 (15). Recorded complications included major and minor access site bleeding and neurologic events within 30 days. Major complications included the need for prolonged hospitalization, unplanned increase in the level of care, permanent adverse sequelae, and death. Specific examples of major complications include blood transfusion, limb ischemia, pseudoaneurysm, and any access site complication requiring open surgical intervention. Minor complications included need for additional nominal therapy and overnight admission for observation, loss of radial pulse without evidence of distal ischemia, and hematoma or blood loss not requiring transfusion or open surgical repair.

Evaluation of the access site was performed before and after the procedure and at 30-day time intervals after the procedure. All patients received a clinical neurologic examination before the procedure, immediately after the procedure, and 30 days after the procedure; any detectable change during this time was also considered a major complication.

Statistical Analysis

Categorical data are reported as number (percentage), and continuous data are reported as either mean (SD) or median (interquartile range) as appropriate. Univariate and multivariate analysis of complications and crossover was performed using logistic regression. Significant univariate predictors were included in a multivariate model. Composite variables were exempted from multivariate analysis. A P value of $< .05$ was considered statistically significant. All statistical analysis was performed using

IBM SPSS Statistics for Windows version 22.0 (IBM Corporation, Armonk, New York).

RESULTS

Of 1,531 procedures evaluated, 1,512 met the inclusion criteria for TRA. Among the 19 cases (1.24%) that were contraindicated for TRA, seven procedures were contraindicated for patients having a prior history of RAO, seven for patients having Barbeau type D waveform, and five for patients having a RA that was < 2 mm in diameter. Technical success was achieved in 1,485 of 1,512 cases (98.2%) in which TRA was attempted.

Among the 936 patients meeting the criteria for TRA, 353 patients (35.8%) had two or more procedures via TRA, constituting 576 cases involving repeat catheterization. Mean time between repeat TRA procedures was 1.8 months (range, 1–20 mo). In one patient, repeat TRA was successfully performed seven times without crossover or complication.

There were overall 38 complications (2.51%) recorded among all TRA cases, of which two (0.13%) met the criteria for major complications. The first major complication was due to a pseudoaneurysm found the next day following the procedure (Fig 2), which was successfully treated with a thrombin injection and resulted in no additional complications. The second major complication was due to a convulsive episode lasting 3 minutes immediately after injection of an antispasmodic solution to prepare the RA (12), but before catheterization, and was resolved after injection of naloxone. The intended procedure was successfully completed without crossover. There were 36 minor complications (2.38%) with hematoma or bleeding (n = 13) and RAO (n = 11) as the first and second most common, respectively (Table 3). All of these complications were either asymptomatic or managed conservatively.

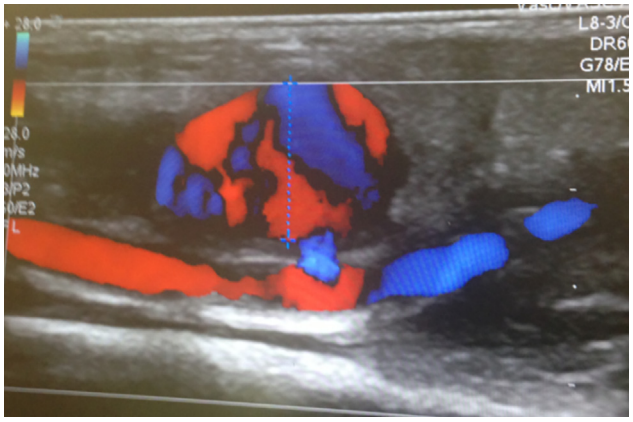


Figure 2. Pseudoaneurysm discovered on postoperative day 2 after TRA for chemoembolization. The arterial wall defect was successfully treated with a thrombin injection and resulted in no additional complications.

A univariate analysis of TRA complications is presented in Table 4. African American ethnicity was associated with a lower rate of TRA complications (P = .027). There was no correlation between repeat TRA

Table 3. Complications

Characteristic	Number (%)
Major	
Pseudoaneurysm/pain	1 (0.07)
Seizure	1 (0.07)
Minor	
Hematoma or bleeding	13 (0.86)
Spasm	6 (0.40)
RAO	11 (0.73)
Arm pain	6 (0.40)
Total	
Major	2 (0.13)
Minor	36 (2.38)

RAO = radial artery occlusion.

Table 4. Analysis of Complications

Predictor	Category	OR (95% CI)	*P*
Age (y)	< 65	1.00	.159
	≥ 65	1.59 (0.83–3.04)	
Sex	Female	1.00	.128
	Male	0.60 (0.32–1.16)	
Ethnicity	White	1.00	—
	African American	0.25 (0.07–0.86)	.027*
	Hispanic	0.39 (0.13–1.14)	.086
	Asian	0.92 (0.34–2.48)	.864
	Other	1.01 (0.40–2.56)	.98
Intervention	Hepatic IO	1.00	—
	UFE	0.69 (0.16–2.93)	.615
	Renal/visceral	0.94 (0.33–2.70)	.902
	Peripheral	1.9 (0.44–8.31)	.384
	Endoleak repair	4.34 (0.54–35.6)	.169
Prior TRA	Naïve	1.00	—
	1	0.97 (0.46–2.01)	.880
	2	1.00	1.00
	> 2	1.00	1.00
Sheath size (F)	4	1.00	—
	5	1.79 (0.42–7.56)	.429
	6	3.45 (0.66–18.11)	.144
Weight (kg)	≤ 75	1.00	.100
	> 75	0.58 (0.30–1.11)	
Height (m)	≤ 1.7	1.00	.532
	> 75	0.81 (0.42–1.57)	
BMI (kg/m^2)	≤ 35	1.00	.992
	> 35	1.00 (0.30–3.33)	

BMI = body mass index; CI = confidence interval; IO = interventional oncology (transarterial chemoembolization, radioembolization mapping, and radioembolization treatment); OR = odds ratio; TRA = transradial access; UFE = uterine fibroid embolization.
*Significance at 0.05 level.

interventions and higher complication rates. No other significant predictors of complication rates were identified.

In 27 procedures, a crossover to the femoral artery was required; among these, 12 cases required crossover because of excessive vessel tortuosity and catheter limitations. In an additional 11 cases, successful catheterization was prevented because of preexisting RAO. In an additional four cases, severe arterial spasm necessitated crossover to TFA. Analysis of TFA crossover is presented in Table 5. Crossover rates were found to be significantly higher in female patients ($P = .0055$), patients with height < 1.7 m ($P = .024$), patients with renal/visceral interventions ($P = .0003$), and patients with endoleak repair interventions ($P = .0357$). Multivariate analysis demonstrated the type of intervention to be the only significant predictor of TFA crossover (renal/visceral [hazard ratio, 4.48; 95% confidence interval, 1.84–10.9; $P = .001$); endoleak repair [hazard ratio, 9.54; 95% confidence interval, 1.09–83.8; $P = .042$)].

DISCUSSION

This study presents data from 1,512 consecutive cases of TRA noncoronary interventions performed in 936 patients. The strength of these data lies in the volume and broad range of cases for which TRA was used in a real-world setting at a single-center institution among 15 operators with various levels of TRA case experience. Among these operators, five were considered experienced (> 50 cases performed), and four were moderately experienced (> 10 but < 50 cases). Additionally, data on complications after the procedure were collected prospectively, allowing for more comprehensive detection of minor complications.

Our overall technical success rate of 98.2% (1,485 of 1,512 cases) exceeds the published SIR quality improvement benchmark of 95% (14). All 27 cases (1.78%) that failed were successfully completed via crossover to TFA. The preexisting RAOs that required crossover (n = 11) were subclinical in manifestation and were not detected during patient screening using the modified Barbeau

Table 5. Crossover Analysis

		Univariate		Multivariate	
Predictor	**Category**	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***
Age (y)	< 65	1.00	.6602	—	—
	≥ 65	1.19 (0.55–2.54)		—	
Sex	Female	1.00	.0055*	1.00	.132
	Male	0.33 (0.15–0.72)		0.49 (0.19–1.24)	
Ethnicity	White	1.00	—	—	—
	African American	0.69 (0.21–2.21)	.529	—	—
	Hispanic	1.19 (0.43–3.31)	.737	—	—
	Asian	1.12 (0.30–4.07)	.880	—	—
	Other	1.36 (0.42–4.38)	.609	—	—
Intervention	Hepatic IO	1.00	—	1.00	—
	UFE	1.56 (0.35–7.00)	.562	1.30 (0.27–6.27)	.741
	Renal/visceral	4.91 (2.07–11.7)	.0003*	4.48 (1.84–10.9)	.001*
	Peripheral	4.34 (0.95–19.9)	.059	3.47 (0.75–16.2)	.112
	Endoleak repair	9.88 (1.17–83.7)	.0357*	9.54 (1.09–83.8)	.042*
Prior TRA	Naïve	1.00	—	—	—
	1	0.80 (0.37–2.00)	.626	—	—
	2	0.37 (0.050–2.81)	.339	—	—
	> 2	1.00	1.00	—	—
Sheath size (F)	4	1.00	—	—	—
	5	1.15 (0.26–4.95)	.856	—	—
	6	3.45 (0.66–18.1)	.144	—	—
Weight (kg)	≤ 75	1.00	.384	—	—
	> 75	0.72 (0.33–1.53)		—	
Height (m)	≤ 1.7	1.00	.024*	1.00	.194
	> 1.7	0.37 (0.15–0.88)		0.51 (0.19–1.40)	
BMI (kg/m^2)	≤ 35	1.00	.203	—	—
	> 35	2.02 (0.69–5.93)		—	

BMI = body mass index; CI = confidence interval; IO = interventional oncology (transarterial chemoembolization, radioembolization mapping, and radioembolization treatment); OR = odds ratio; TRA = transradial access; UFE = uterine fibroid embolization.
*Significance at 0.05 level.

screening test (11). Although crossover secondary to anatomic variations such as vessel tortuosity might have been further reduced by imaging before the intervention, the relatively nominal number of these cases requiring crossover and the slight discomfort caused to the patient may not justify the cost and radiation exposure from additional imaging.

Univariate analysis of the crossover rate found procedure type, female sex, and height < 1.7 m to be significant predictors of an increase in crossover incidence. The last-mentioned of these findings is paradoxical given the known catheter length limitations of TRA in noncoronary interventions. A possible explanation is that TRA was preferentially not offered to taller individuals, especially for more complex procedures. The higher crossover rate in female patients in this study is consistent with the analysis of the 2012 RIVAL trial by Pandie et al (16). Multivariate analysis demonstrated only procedure type, specifically renal/visceral interventions and endoleak repairs, to be predictive of increased crossover rate. Given that only 10 endoleak repairs were performed via TRA, the increased crossover rate likely represents a statistical anomaly, as there was only one crossover, or could be due to equipment limitations given the complexity of these interventions. Additionally, approximately 5.2% of renal/visceral interventions required crossover to TFA. Although this is a higher crossover rate compared with other TRA procedures, it is still low, and in our opinion TRA should still be offered to the patient in appropriate scenarios.

The overall complication rate in our study was 2.51%, with a major complication rate of 0.13% (2 of 1,512 cases), which is well below the overall 1.0% suggested threshold for major complications (14). Complications such as arterial occlusion and vasospasm have substantial associated morbidity and are defined as major complications in studies examining transfemoral and transbrachial access. In contrast, these complications proved to be asymptomatic and were considered minor complications because of the dual circulation provided by the ulnar–palmar arch. A meta-analysis of 21 publications (N = 3,662 patients) examining TFA complication rates in noncardiac interventions demonstrated total complication rates of 3.1%–11.4% (17). Although a direct correlation to our study cannot be made, our study demonstrates a lower complication rate than TFA and mirrors findings in PCI literature comparing TRA with TFA. Transbrachial access has also been extensively studied but has become relegated to a secondary access site choice because of unacceptably high major complication rates (18).

There was one major complication in which a patient experienced a seizure lasting 3 minutes. Diagnostic imaging failed to reveal any enhancing brain lesions, evidence of mass or intracranial hemorrhage, or evidence of recent or remote infarction. Following a neurologic consultation, electroencephalography was performed and showed abnormal left temporal slowing. This complication resolved fully, and the patient was asymptomatic during a follow-up office visit at 30 days. Seizure after verapamil administration has been described in the literature as an exceedingly rare complication (19).

The impact of access site choice on neurologic complications has been extensively studied. A propensity score analysis of 16,710 cases from 2006 to 2012 demonstrated that neurologic complications after cardiac catheterization remained constant at 0.16%, although the rate of TRA adoption versus TFA increased from 0.7% in 2006 to 75% in 2012 (20). Similar complication rates after TRA have been extensively published relating to PCI, suggesting that there is no significant difference between TRA and TFA regarding neurologic complications. The cardiac patient profile typically includes higher risk of significant atherosclerosis and coronary artery disease, and coronary interventions typically require considerably more manipulations across the aortic arch in these patients. Although not detected in our study, a subclinical risk of microemboli exists secondary to arch manipulation. This risk represents a limitation in our study because these microemboli and associated subclinical neurologic deficits could be missed and cause the overall complication rate to be underreported. The left RA is always preferred for subdiaphragmatic interventions because this pathway crosses only the left vertebral artery and not the carotid arteries. Further research is needed to evaluate the correlation between access site and neurologic events in a typical interventional radiology patient population.

Minor complications in our study included hematoma or excess bleeding treated conservatively (n = 13), RAO (n = 11), arm pain treated with nonsteroidal antiinflammatory drugs (n = 6), and arterial spasm (n = 6). All cases were asymptomatic or resolved completely at 30 days. RAO is of particular interest because this was discovered only in patients undergoing repeat intervention. Although all patients evaluated in the study demonstrated radial pulse distal to the access site during a follow-up office visit within approximately 30 days, subclinical cases of RAO would not be detected using the Barbeau test, as pulse can be transmitted via the palmar arches retrograde to the RA via the ulnar circulation. Consequently, these events would be significantly underreported. Although rarely symptomatic, RAO has been reported in the literature to be between 4% and 12% (13). Failure to detect these cases in this study represents a major study limitation.

Although patients were asymptomatic after the procedure and during follow-up, the long-term consequences of RAO are unclear. Literature shows that patients with RAO remained asymptomatic at 3 months (21) and at longer term follow-up of 6–12 months (22). There has

also been evidence suggesting that RA catheterization can lead to late-term narrowing of the lumen and impaired vasodilatory response (23), although the clinical implications of these changes are unclear. Lastly, we did not see any hand ischemia, and reports of ischemic changes are exceedingly rare in cardiac literature. To date, there have been only two case reports describing mild ischemic changes including paresthesia and numbness after TRA for cardiac catheterization; however, symptoms were reversed without long-term complications after revascularization (24,25).

We did not find any relationship between repeat catheterization and complications. There were 343 patients who underwent repeat TRA and accounted for 18 of the 36 total minor complications (50.0%); these patients had no major complications. In four cases, a prior TRA complication resulted in RAO and required crossover during the next procedure; in nine cases, repeat TRA was carried out successfully after discovery of an occlusion during catheterization. These findings are consistent with findings in published literature, where high-volume centers reported repeat TRA with success rates of $>$ 95% (26–28). One study reported higher rates of asymptomatic RAO in patients undergoing repeat catheterization (26); this was not seen in our study. Successful repeat TRA in 680 of 4,818 consecutive patients was reported by Valsecchi and Vassileva (27) from 70 minutes after initial intervention to 6 years after initial intervention and was described to be repeated in one patient seven times. We also successfully demonstrated repeat catheterization in a patient via TRA seven times.

This study has major limitations and is subject to bias. Patients were selected for TRA in a nonrandom manner and subject to a selection bias. Patients who were better suited for TFA were not offered the option of TRA, and patients with body mass index $>$ 30 were preferentially offered TRA. Among the patients initially offered TRA, 1,524 of 1,531 (99.5%) displayed a non–D pulse waveform, which is consistent with prior studies (11). Operator preference was also a determining factor in whether a patient was offered TRA or TFA. This study is also subject to a proficiency bias. Given that our institution is a high-volume center with extensive experience using TRA, it is possible that our complication rate would be difficult to replicate elsewhere without adequate experience and training. Additionally, the risk of subclinical complications that went undetected in our study represents a potential source of reporting bias. Lastly, procedural time and radiation dose exposure were not documented in our study. Future studies could address these limitations to validate conclusions about the potential clinical benefits of using TRA compared with TFA for noncoronary interventions.

In conclusion, our study demonstrates the safety and applicability of TRA in a real-world setting in a heterogeneous patient population across a broad range of peripheral interventions. TRA was technically successful in 98.2% of cases and showed an overall complication rate of 2.51% and a major complication rate of 0.13%. TRA is a promising alternative primary access site to TFA.

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