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A reality check in transradial access: a single-centre comparison of transradial and transfemoral access for abdominal and peripheral intervention

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Abstract

Objectives The purpose of this study was to describe a single institution's experience with transradial access (TRA) for angiographic interventions, and to compare technical success, complication rate and radiation dose of procedures performed with TRA to those performed with transfemoral access (TFA).

Methods A retrospective cohort study of patients undergoing peripheral interventions via TRA or TFA from 2015 to 2017 was performed. The cohort comprised 33 patients undergoing 44 procedures via TRA and 37 patients undergoing 44 procedures via TFA. Outcome measures were technical success, access-related complications, fluoroscopy time and radiation exposure. Differences at $p < 0.05$ were considered to be statistically significant.

Results Baseline characteristics were similar between patients who had procedures via TRA versus those who had procedures via TFA, including age, sex and body mass index. Technical success was achieved in 41/44 (93.2%) of procedures performed via TRA, compared to 44/44 (100%) of procedures performed via TFA ($p = 0.241$). There were three access-related complications (6.8%) when TRA was performed, compared to none when TFA was performed ($p = 0.241$). Fluoroscopy time was longer in procedures performed with TRA compared to those performed with TFA (27.3 vs 20.4, $p = 0.033$). Dose area product (DAP) did not differ with access site choice ($p = 0.186$).

Conclusions TRA is a safe and feasible alternative to TFA for a range of peripheral interventions. However, TRA must be performed with prudence as it is not without complications and is technically challenging, leading to longer fluoroscopy time.

Key Points

- *Transradial access (TRA) is feasible in a variety of peripheral interventions, achieving success in 93.2% of cases.*
- *Access-related complications are comparable between transfemoral access (TFA) and TRA ($p = 0.241$), but prudence must be taken during TRA as it could be technically challenging.*
- *Procedures performed with TRA tend to have longer fluoroscopy time compared to those performed with TFA ($p = 0.033$), but the DAPs are comparable ($p = 0.186$).*

Keywords Radial artery access · Femoral artery access · Interventional radiology · Embolisation · Vascular access

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Abbreviations

DAP	Dose area product
PCI	Percutaneous coronary intervention
TACE	Transarterial chemoembolisation
TFA	Transfemoral access
TRA	Transradial access

Introduction

The growing body of evidence over the past decade has increasingly supported transradial access (TRA) for arteriography, a technique first described by Lucien Campeau in 1989 [1] as a safe and effective alternative to transfemoral access (TFA). Potential advantages of TRA include: (1) fewer bleeding and vascular complications; (2) patient preference; (3) reduced cost; (4) faster time to discharge [2–8]. These benefits have led to the adoption of TRA by the interventional cardiology community. In 2013, transradial percutaneous coronary intervention (PCI) accounted for one of six PCIs performed in the United States, a drastic change from the previously reported 1.32% usage rate from 2004 to 2007 [9].

The success of TRA for PCIs prompted single-centre studies which have described the safety and feasibility of TRA for peripheral and systemic interventions [10, 11], reporting technical success rates as high as 98.2% and major and minor complication rates of 0.13% and 2.38%, respectively. However, TFA remains the access site of choice for the majority of non-coronary interventions across the United States. To date, only two studies have directly compared TRA to TFA for non-coronary procedures [12, 13], but each study elected to restrict their scope to patients undergoing a single type of procedure.

Given the scarcity of evidence supporting TRA for peripheral interventions, we aim to describe our initial experience with TRA for peripheral arterial interventions, and compare technical success, complication rate and radiation dose parameters of procedures performed with TRA to those performed with TFA. We hypothesise that peripheral interventions performed with TRA can be conducted with an acceptable complication rate and limited radiation exposure without compromising technical success.

Materials and methods

This single-centre study was approved by the institutional review board at our hospital and is compliant with the Health Insurance Portability and Accountability Act, with waiver of informed consent.

A retrospective cohort analysis was conducted on 44 consecutive angiograms of 33 patients with attempted TRA and 44 angiograms of 37 patients with attempted TFA. The first three procedures with attempted TRA were bone embolisations performed in 2015, which served as our institution's index cases for TRA. After it was confirmed that these procedures were without complication, TRA was adopted with more regularity and the remaining 41 procedures with TRA were performed between June 2016 and June 2017. The cases performed with TFA were non-consecutive, completed between March 2013 and July 2017, and chosen to match the cases performed with TRA with respect to patient age and procedure type. The technical success of the TFA cases was not known prior to data analysis. All procedures were performed by a single interventionalist with 7 years of interventional radiology experience to eliminate differences in procedural technique that could impact outcomes. The interventionalist learned TRA through a course during the 5th year of practice. Philips fluoroscopy units were used for all procedures, without the use of cone beam computed tomography. All patients received conscious sedation.

The data collected included age, sex, height, weight, body mass index (BMI), medical comorbidities, procedure performed, equipment used, fluoroscopy time, air kerma and DAP measured with the manufacturer's DAP meter (Philips Healthcare, Andover, MA, USA). Technical success was defined as successful access and completion of intended procedure without crossover to a different access site. Complications were noted in accordance with the corresponding quality improvement guidelines published by the Society of Interventional Radiology for each procedure. Major complications included those requiring therapy and minor hospitalisation (48 h), those requiring major therapy with an unplanned increase in level of care and prolonged hospitalisation, permanent adverse sequelae and death [14]. Minor complications included those without clinical consequence and required nominal therapy at most. Access-related complications included those related to the access point at the skin and those related to catheter access at branched arteries.

Individual chart review was conducted to monitor for complications as above, subjective complaints, documentation of a vascular and neurological exam, as well as all vascular imaging studies.

TRA technique

Patients were evaluated for ulnopalmar arterial arch patency using the Barbeau test [15]. Figure 1 depicts each of the possible waveforms that may be observed on pulse oximetry when performing the Barbeau test. Standard exclusion criteria for TRA, including Barbeau waveform D, radial artery diameter <2 mm on ultrasound and need for dialysis, were applied. No patients were excluded under these criteria. Patients were supine on the angiography table with the left arm abducted onto an arm board or adducted over the left groin area. The patient's wrist was hyperextended with the palm faced up. The left radial artery was accessed, except for two bone embolisations which required an ipsilateral approach from the right. Access was achieved with a 21-gauge needle under ultrasound guidance and a 0.018" guidewire was advanced. Once the position of the wire was confirmed under fluoroscopy, the needle was exchanged for a hydrophilic sheath (Glidesheath Slender, Terumo Medical Corporation, Somerset, NJ, USA; Prelude Ease, Merit Medical Systems,

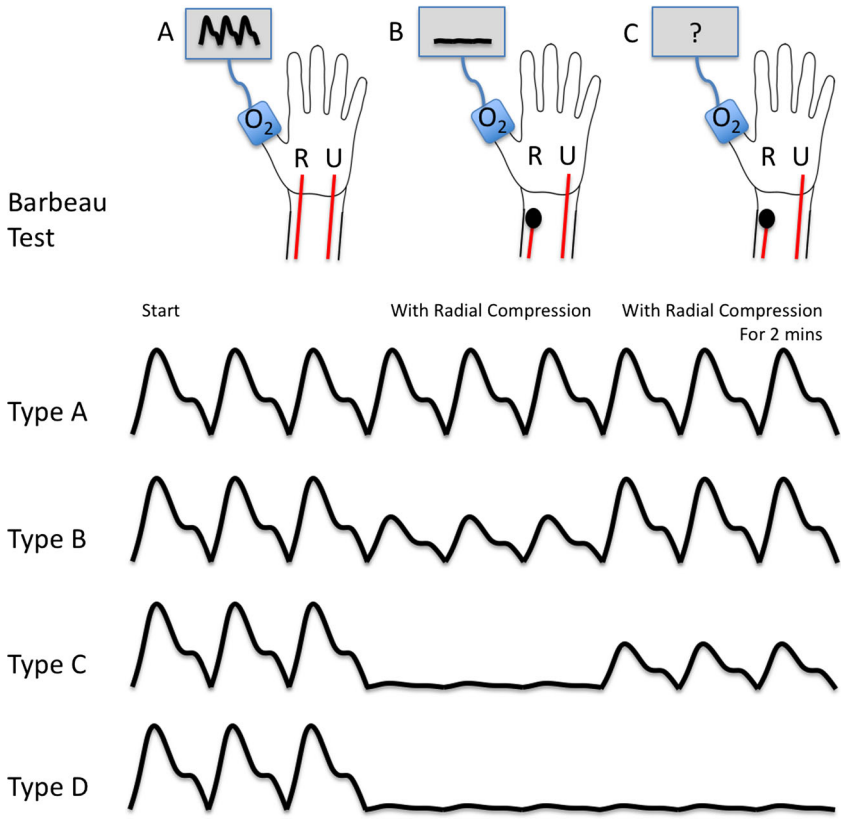

Fig. 1 An illustration of Barbeau test. **a** Before the radial artery access, the pulse oximeter should be placed in the thumb of the accessing arm. **b** Once the pulse oximeter is showing the tissue oxygen saturation level and its waveform, the radial artery should be compressed firmly to completely occlude the vessel and therefore, the waveform changes accordingly. These are the possible changes: (1) a minimal to no change in waveform (Type A); (2) the waveform dampens for a short period but almost completely returns to the normal waveform (Type B); (3) the waveform almost completely disappears but returns within 2 min; however, it stays dampened (Type C); (4) the waveform completely disappears and stays no oxygen saturation (Type D). In only Type D patients, the radial access should not be performed

Malvern, PA, USA). Following access, a vasodilator cocktail consisting of 2,000 IU heparin and 200 μg nitroglycerin was administered in a haemodilutional fashion. Radial-specific diagnostic catheters as well as basic angled catheters, ranging from 100-150 cm, were used for all procedures. Following completion of the procedure and removal of all vascular devices, haemostasis was achieved using a compression device (TR Band; Terumo Medical Corporation) placed over the arteriotomy site. Patients were able to ambulate as tolerated, and the compression device was released over time according to the manufacturer's instructions.

Statistics

Significant differences between groups were analysed by the Student *t*-test, Fisher exact test and χ^2 test. $P < 0.05$ was considered to be statistically significant. Actual measurements are expressed as mean value ± standard deviation.

Results

Baseline clinical characteristics

Our cohort consisted of 33 patients (25 men, 8 women; mean age, 57 ± 17 years) who underwent 44 angiograms with planned TRA and 37 patients (24 men, 13 women; mean age, 58 ± 12 years) who underwent 44 angiograms with planned TFA. The mean age of the entire cohort was 57 years. The groups did not differ significantly with respect to age, sex, weight, height or BMI (Table 1). The two groups were balanced with respect to medical comorbidities. The distribution of procedures for each group consisted of 12 Y90 mappings, 11 Y90 radioembolisations, 11 transarterial chemoembolisations (TACE), and 3 bone embolisations. The mean follow-up for the entire cohort was 6 months.

Fluoroscopy time and radiation dose

The fluoroscopy time in procedures performed with TRA was significantly longer compared to the fluoroscopy time in procedures performed with TFA (27.3 min vs 20.4 min, $p = 0.033$; Table 2). Procedures performed with TRA resulted in similar radiation exposure to the patient as those performed with TFA, as the difference in dose area product was insignificant ($p = 0.186$; Table 2).

Technical success and complications

Technical success was achieved in 93.2% of cases in the TRA group and 100% of cases in the TFA group ($p = 0.241$). Of the three procedures considered technical failures in the TRA group, one was related to unsuccessful access. In this case, needle access of the radial artery was achieved, but a

Table 1 Baseline clinical characteristics of the procedures

	TRA (n = 44)	TFA (n = 44)	p value
Age (years)	57 ± 17	58 ± 12	0.728
Sex (male), n (%)	34 (77)	29 (66)	0.237
Weight (kg)	76 ± 21	77 ± 18	0.881
Height (m)	1.73 ± 0.10	1.73 ± 0.09	0.851
BMI (kg/m^2)	25.4 ± 6.1	25.5 ± 4.7	0.950
Comorbidities, n (%)			
Malignancy	43 (98)	40 (91)	
CAD	5 (11)	5 (11)	
Vasculitis	1 (2)	1 (2)	
Cirrhosis	10 (23)	7 (16)	
CKD	3 (7)	6 (14)	
Hypertension	20 (45)	17 (39)	
Diabetes mellitus	10 (23)	13 (30)	
Atrial Fibrillation	3 (7)	2 (5)	
Intervention, n (%)			
Y90 mapping	12 (27)	12 (27)	
Y90 embolisation	11 (25)	11 (25)	
Transarterial chemoembolisation	11 (25)	11 (25)	
Bone embolisation	3 (7)	3 (7)	
Mesenteric embolisation	3 (7)	7 (16)	
Pelvic embolisation	1 (2)	0 (0)	
Diagnostic angiogram	3 (7)	0 (0)	
Sheath size (F), n (%)			
4	3 (7)	0 (0)	
5	35 (80)	2 (5)	
6	6 (14)	42 (95)	

Data presented as mean ± SD as appropriate

BMI body mass index, *GIST* gastrointestinal stromal tumour, *CAD* coronary artery disease, *CKD* chronic kidney disease

guidewire could not be passed. Two procedures in the TRA group required crossover to femoral access after successful radial access. In one case, the patient developed intractable arm pain. In another procedure, a TACE, the catheter system was of insufficient length to both subselect tertiary branches off the splenic artery supplying the hepatic tumour and spare branches supplying the right colon.

There were three access-related complications in the TRA group and none in the TFA group (p = 0.241; Table 3). The single major access-related complication in the TRA group was a common hepatic artery dissection and occlusion. There were two minor access-related complications in the TRA group related to the access site at the skin; one patient had arm pain as described above, and another developed radial artery occlusion (RAO) confirmed by ultrasound. The patient who developed RAO had two prior procedures with successful radial access. There were no observed pseudoaneurysms, haematomas or bleeding complications in either group.

Discussion

The present study demonstrates that TRA is an acceptable alternative to TFA for peripheral interventions. We found that the procedures in our study have comparable technical success and complication rates, regardless of the access site. However, procedures performed with TRA required longer fluoroscopy time.

While the majority of the procedures in our study were either hepatic interventions or mesenteric embolisations, the safety and feasibility of TRA have been described for a number of other peripheral interventions, including uterine artery embolisation [16] and renal artery intervention [17]. In addition to citing high technical success rates and low complication rates, the interventional radiology literature also reports cost savings of $100 per procedure [13] performed with TRA vs TFA, and an overwhelming 98% patient preference of TRA over TFA [11].

To our knowledge, Shiozawa et al [12] and Kis et al [13] are the only studies to date that compare TRA to TFA in the

Table 2 Fluoroscopy time and radiation dose

	TRA (n = 44)	TFA (n = 44)	p value
Fluoroscopy time (min)	27.3 ± 17.7	20.4 ± 11.7	0.033
Dose area product (mGy × cm^2)	689,530 ± 579,254	544,344 ± 431,372	0.186
Air kerma (mGy)	2,396 ± 2131	2,148 ± 1,974	0.574

Data presented as mean ± SD as appropriate

peripheral circulation. The technical success rates of TRA in these reports were 98.3% and 100%, respectively. Larger series studying TRA for peripheral interventions report technical success rates of 98.2% [10] to 99.5% [11]. While the technical success rate of 93.2% in our study is not as high as these reported rates, it approximates the published SIR quality improvement benchmark of 95% [18].

With respect to access site complications, Shiozawa et al reported a 4.6% minor complication rate in the TRA group and a 12.7% complication rate in the TFA group. In contrast, Kis et al reported a 9% minor complication rate in the TRA group and had no complications with procedures performed with TFA. In our study, there was a nonsignificant difference in minor access-related complications between the TRA and TFA groups (4.5% vs 0%). There was one common hepatic artery dissection that was considered to be the only major radial access-related complication in our cohort. The angle of approach required by transradial access may have contributed to the development of this complication. The rate of femoral access site complications is variable in the literature. According to a meta-analysis by Das et al [19] of 21 studies (3,662 patients) examining non-cardiac interventions, TFA complication rates range from 3.1 to 11.4%. This further supports our finding that TRA is at least as safe as TFA.

There were no patients in our cohort presenting with neurological symptoms or deficits in the follow-up period to suggest ischaemic stroke. However, this does not exclude the possibility of subclinical neurological deficits secondary to microemboli. A meta-analysis by Patel et al [20] reports identical rates of stroke (~0.4%) after cardiac catheterisation performed via TRA or TFA. The theoretical risk for TRA performed for peripheral interventions is likely lower, because the cardiac patient tends to have a higher degree of atherosclerosis and requires manipulation across a greater number of aortic arch branches. The use of TRA for peripheral interventions is still in its infancy compared to the use of TRA for cardiac catheterisations. However, only one incident of stroke has been reported in the literature so far for subdiaphragmatic interventions performed with TRA [21]. Despite the low overall risk of an adverse neurological event, the consequences are potentially devastating. We therefore recommend using the left radial artery for access rather than the right radial artery, in order to avoid the carotid vessels.

Kis et al also compared the fluoroscopy time and radiation dose with TRA vs TFA. Our study is in agreement with their finding of longer fluoroscopy times in procedures performed with TRA. The longer fluoroscopy time can be partially explained by the longer catheter system necessitated by a transradial approach and the tortuous path that must be traversed from the radial access site to major abdominal aortic branches. These factors add complexity for the operator not only because of the extra distance that must be covered, but also the mechanical disadvantage imposed by reduced pushability. Inexperience of the operator is another factor to consider. The fluoroscopy time did not differ for procedures performed with TRA when comparing the first and second halves of the study period. Although this may argue against the existence of a learning curve, a study of radial operator experience in PCIs suggests that the threshold to overcome the learning curve is 30-50 cases [22]. Thus, the difference in fluoroscopy time may diminish with higher case volume. In contrast to Kis et al's findings, we did not find that longer fluoroscopy times translated to higher radiation doses. However, it is possible that the radiation to the operator is

Table 3 Complications

	TRA (n = 44)	TFA (n = 44)	p value
Total access-related complications, n (%)	3 (6.8)	0 (0)	0.241
Major access-related complications, n (%)	1 (2.2)	0 (0)	1.000
Common hepatic artery dissection	1	0	
Pseudoaneurysm	0	0	
Minor access-related complications, n (%)	2 (4.5)	0 (0)	0.494
Radial artery occlusion	1	N/A	
Arm pain	1	N/A	
Haematoma/bleeding	0	0	
Spasm	0	N/A	

decreased in procedures performed with TRA. Due to the patient's positioning during TRA, the operator usually stands at the patient's abducted left arm, which is farther from the radiation source compared to cases performed with TFA where the operator stands closer to the abdomen. Our study did not directly measure radiation exposure to the interventionalist, but this could be an area of future study.

Our study has several limitations. We only report a single institution's experience, not accounting for heterogeneity across practices. Our sample size precluded subgroup analysis and may have limited the power of the study to detect small differences between the two groups. The retrospective nature of the study may have limited the detection of more subclinical complications. In particular, the rate of RAO is likely underestimated in this study due to lack of follow-up Doppler ultrasound. The literature suggests that the rate of RAO may be as high as 15% [23]. The one case of RAO in this study was detected during attempt of TRA at repeat intervention. Indeed, the vast majority of RAO cases are asymptomatic, and signs of hand ischaemia are exceedingly rare. Finally, in order to match the groups with respect to age and procedure type, the included procedures performed with TFA were non-consecutive, which could potentially introduce selection bias.

In conclusion, the present study demonstrates the early safety and feasibility of TRA for a range of peripheral interventions, supporting the published literature. TRA is technically challenging, leading to longer fluoroscopy times compared to TFA. However, TRA has several advantages over TFA, and should be considered an acceptable alternative for access.

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Compliance with ethical standards

Guarantor The scientific guarantor of this publication is Edward W. Lee, MD, PhD.

Conflict of interest The authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article.

Statistics and biometry No complex statistical methods were necessary for this paper.

Informed consent Written informed consent was waived by the Institutional Review Board.

Ethical approval Institutional Review Board approval was obtained.

Methodology
- retrospective
- case-control study
- performed at one institution

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