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Mechanism and Predictors of Failed Transradial Approach for Percutaneous Coronary Interventions

Payam Dehghani, MD,* Atif Mohammad, MD,* Ravi Bajaj, BSc,* Tony Hong, BSc,* Colin M. Suen, BSc,* Waseem Sharieff, MD,† Robert J. Chisholm, MD,* Michael J. B. Kutryk, MD, PhD,† Neil P. Fam, MD, MSc,* Asim N. Cheema, MD, PhD*

Toronto, Ontario, Canada

Objectives The study aimed to determine the mechanism and predictors of procedural failure in patients undergoing percutaneous coronary intervention (PCI) from the transradial approach (TR).

Background Transradial approach PCI reduces vascular complications compared with a transfemoral approach (TF). However, the mechanism and predictors of TR-PCI failure have not been well-characterized.

Methods The study population consisted of patients undergoing TR-PCI by low-to-intermediate volume operators with traditional TF guide catheters. Baseline characteristics, procedure details, and clinical outcomes were prospectively collected. Univariate and multivariate analyses were performed to determine independent predictors of TR-PCI failure.

Results A total of 2,100 patients underwent TR-PCI and represented 38% of PCI volume. Mean age was 64 ± 12 years, and 17% were female. Vascular complications occurred in 22 (1%), and TR-PCI failure was observed in 98 (4.7%) patients. The mechanism of TR-PCI failure included inability to advance guide catheter to ascending aorta in 50 (51%), inadequate guide catheter support in 35 (36%), and unsuccessful radial artery puncture in 13 (13%) patients. The PCI was successful in 94 (96%) patients with TR-PCI failure by switching to TF. On multivariate analysis, age >75 years (odds ratio [OR]: 3.86; 95% confidence interval [CI]: 2.33 to 6.40, p = 0.0006), prior coronary artery bypass graft surgery (OR: 7.47; 95% CI: 3.45 to 16.19, p = 0.0002), and height (OR: 0.97; 95% CI: 0.95 to 0.99, p = 0.02) were independent predictors of TR-PCI failure.

Conclusions Transradial approach PCI can be performed by low-to-intermediate volume operators with standard equipment with a low failure rate. Age >75 years, prior coronary artery bypass graft surgery, and short stature are independent predictors of TR-PCI failure. Appropriate patient selection and careful risk assessment are needed to maximize benefits offered by TR-PCI. (J Am Coll Cardiol Intv 2009;2:1057–64) © 2009 by the American College of Cardiology Foundation

From the *Terrence Donnelly Heart Center, St. Michael's Hospital, and the †Department of Health Policy, Management, and Evaluation, University of Toronto, Toronto, Ontario, Canada.

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The transradial approach (TR) for percutaneous coronary intervention (PCI) has been shown to decrease vascular complications and improve clinical outcomes compared with transfemoral approach (TF) in both young (1) and elderly patients (2). The TR-PCI is associated with a lower risk of access site bleeding and hematoma (3,4), early patient ambulation (5), shorter length of hospital stay (6), and lower hospital costs (7,8). However, despite demonstrated benefits, TR is employed in a minority of patients undergoing PCI. A recent analysis of the National Cardiovascular Data Registry with more than 600 participating sites performing PCI across the U.S. reported use of TR-PCI in <1.5% of all PCI procedures (1). Technical difficulties and challenges encountered during TR-PCI, particularly in low-to-intermediate volume operators, are thought to be a major reason for underuse of this technique. This perception is further enhanced because most studies reporting on feasibility and success of TR-PCI were performed by high-volume operators. Several small studies have reported the superiority of TR for diagnostic catheterizations (9), elective PCI (10), primary PCI (11), and rescue PCI (12) compared with TF. However, the mechanism and predictors of TR-PCI failure have not been well-characterized. In this study, we investigate the mechanism and predictors of TR-PCI failure in a large cohort of patients.

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Abbreviations and Acronyms

BMI = body mass index

CABG = coronary artery bypass graft surgery

CI = confidence interval

LCA = left coronary artery

OR = odds ratio

PCI = percutaneous coronary intervention

RCA = right coronary artery

TF = transfemoral approach

TIMI = Thrombolysis In Myocardial Infarction

TR = transradial approach

Methods

Study population. All patients undergoing TR-PCI from June 2002 to June 2006 at St. Michael's hospital were included in the study. All procedures were performed by 14 low-to-intermediate volume TR-PCI operators. Annual TR-PCI volume ranged from 8% to 42% of total annual PCI volume for all operators. The choice of arterial access used in an individual patient was at the discretion of the operating physician. All patients with an abnormal Allen's test, clinically assessed to have radial artery too small for 6-F guide, or presenting with cardiogenic shock were excluded. The TR-PCI in patients with prior coronary artery bypass graft surgery (CABG) was performed only if the target lesion was located in a native coronary artery or saphenous vein graft that had been identified in a previous TF coronary angiogram.

Definitions. Procedural success was defined as completion of a PCI procedure from TR with <10% residual stenosis and Thrombolysis In Myocardial Infarction (TIMI) flow grade 3 in the intervened artery. A TR-PCI failure was defined as inability to complete a PCI procedure by TR. Vascular spasm was defined as inability to manipulate arterial sheath, guidewire, or guide catheter in a smooth and pain-free manner (13). Access site bleeding was defined as per TIMI criteria (14). Access site complication was defined as bleeding >3 g/dl, presence of hematoma >5 cm, or need for blood transfusion or vascular repair. Guide catheter use was calculated separately for the left (LCA) and the right coronary artery (RCA).

TR-PCI technique. The radial artery was cannulated with the arm positioned beside the patient's body using an arm rest with the wrist in a slightly hyperextended position. Local anesthetic (3 to 5 ml) was injected subcutaneously with a 25-gauge needle followed by puncture of the radial artery with a short-beveled 20-gauge needle. A soft 0.025-inch straight guidewire was advanced through the needle, and a 6-F, 23-cm radial sheath (Cordis Corporation, Miami, Florida) was placed. Intra-arterial verapamil (2.5 mg) or nitroglycerin (200 to 400 μm) was administered after obtaining arterial access. The PCI was performed with 6-F traditional guide catheters (Boston Scientific Corporation, Natick, Massachusetts, or Medtronic, Inc., Maple Grove, Minnesota) used for TF. Hydrophilic radial sheaths or specially designed radial guide catheters were not used. Selective angiography of a radial, brachial, or subclavian artery was performed when difficulty was encountered in advancing guidewire or the guide catheter. All patients received 160 to 325 mg of aspirin, a loading dose of clopidogrel (300 or 600 mg), and unfractionated heparin at 70 U/kg of body weight. Additional heparin was administered during PCI to keep activated clotting time (ACT) values above 250 s. Glycoprotein IIb/IIIa platelet receptor antagonists and direct thrombin inhibitors were administered at the discretion of the operating physician. The radial artery sheath was removed immediately after completion of TR-PCI, and hemostasis was achieved by application of an adjustable plastic clamp on the radial artery. The clamp was gradually released over 2 to 3 h while monitoring for access site bleeding or hematoma. The clamp was removed after satisfactory access site hemostasis had been achieved.

Statistical analysis. Descriptive statistics (mean, SD, median, range, proportion) and graphs (histograms, bar charts) were used for initial analysis. Modified Student *t* test was used for comparison of continuous data, chi-square test was used for comparison of dichotomous data, and Wilcoxon rank sum test was used for comparison of ordinal data between successful and failed TR-PCI. Log transformations were applied to normalize skewed data. Stepwise multiple logistic regression models were used to determine predictors of TR-PCI failure. Independent variables in these models

Table 1. Baseline Characteristics

	TR-All (n = 2,100)	TR-Success (n = 2,002)	TR-Failure (n = 98)	p Value*
Age	64 ± 12	62 ± 11	67 ± 13	<0.001
Female sex	357 (17)	329 (16)	26 (26)	0.009
BMI	28 ± 5	29 ± 5	29 ± 5	NS
Height, cm	170 ± 9	170 ± 9	166 ± 10	<0.001
Diabetes	405 (19)	381 (19)	24 (24)	NS
Hypertension	1165 (55)	1101 (55)	64 (64)	NS
Dyslipidemia	1092 (52)	1030 (52)	61 (62)	NS
Renal insufficiency	153 (7)	140 (7)	13 (13)	NS
Prior PCI	180 (8.6)	168 (8)	12 (12)	NS
Prior CABG	64 (3.0)	52 (2.6)	11 (11)	<0.001
Indication for PCI				
Stable angina	1,295 (62)	1,234 (62)	61 (61)	NS
UA/NSTEMI	683 (32)	576 (29)	33 (34)	NS
STEMI	122 (6)	118 (6)	4 (4)	NS

Values are n (%) or mean ± SD. *Compared with transradial approach (TR)-success.
BMI = body mass index; CABG = coronary artery bypass surgery; NSTEMI = non–ST-segment elevation myocardial infarction; PCI = percutaneous coronary intervention; STEMI = ST-segment elevation myocardial infarction; UA = unstable angina.

included all clinically important variables, such as age >75 years, male sex, body mass index (BMI) >25 kg/m^2, height, acute coronary syndrome, and prior history of PCI or CABG. When a continuous variable was significantly associated with outcome, it was further analyzed by quartiles for a clinically meaningful interpretation. In addition, stepwise multiple linear regression models were applied to examine whether the same clinically important variables were also significantly associated with fluoroscopy time and contrast volume use in TR-PCI success group. All analyses were performed with SAS version 9.1 (SAS Institute, Cary, North Carolina). A p value <0.05 was considered statistically significant.

Results

A total of 2,100 patients were included in the study. This represented 38% of total PCI patient population during the study period. Three hundred fifty-seven patients (17%) were women, and the mean age of the study group was 64 ± 12 years. The PCI could not be completed by TR in 98 patients (4.6%) and included 26 women (7%) and 72 men (4%). Immediate crossover to TF was employed in all TR-PCI failures and allowed successful completion of PCI in 94 (96%) patients with an overall success rate of >99%.

The baseline characteristics of the study population are described in Table 1. The patients in the TR-PCI failure group were significantly older (67 ± 13 years vs. 62 ± 11 years, p <0.001), more likely to be women (26% vs. 16%, p = 0.009), and of shorter height (166 ± 10 cm vs. 170 ± 9 cm, p < 0.001) compared with the successful TR-PCI group. There was no difference in number of patients undergoing multivessel or bifurcation PCI and use of glycoprotein IIb/IIIa platelet receptor antagonist.

The procedural characteristics are shown in Table 2. A mean of 1.3 ± 0.6 coronary arteries were treated per patient. The number of guide catheters used for PCI of LCA or RCA was significantly higher in TR-PCI failure compared

Table 2. Procedural Characteristics

	TR-All (n = 2,100)	TR-Success (n = 2,002)	TR-Failure (n = 98)	p Value
Intervened coronary artery				
LAD	1,018 (48)	973 (49)	45 (46)	NS*
LCX	603 (29)	571 (28)	32 (33)	NS*
RCA	822 (39)	790 (39)	34 (35)	0.01*
Multivessel PCI	432 (21)	409 (20)	23 (23)	NS*
Bifurcation PCI	42 (2)	40 (2)	2 (2)	NS*
Heparin dose, U/kg	6,000 (0–15,600)	6,000 (0–13,000)	6,000 (0–15,600)	NS*
Fluoroscopy time, min	11 (2–91)	11 (2–91)	13 (4–89)	<0.01†
Contrast volume, ml	170 (10–820)	170 (10–800)	205 (75–820)	<0.0006†
GP IIb/IIIa	1,596 (76)	1,521 (76)	67 (68)	NS
Procedural success	2,096 (99)	—	94 (96)	
Vessels treated/patient	1.3 ± 0.6	1.3 ± 0.5	1.3 ± 0.7	NS‡
No. of guides				
Per patient	1.5 ± 0.9	1.5 ± 0.8	2.0 ± 1.2	<0.0001‡
For RCA	1.2 ± 0.5	1.2 ± 0.6	1.4 ± 0.6	0.003‡
For LCA	1.2 ± 0.6	1.2 ± 0.6	1.6 ± 1.0	<0.0001‡
Stent/patient	1.5 ± 1	1.6 ± 1	1.8 ± 1	0.03‡

Values are n (%), median (range), or mean ± SD. Chi-square and modified *t* test on *actual and †logarithmic scale. ‡Wilcoxon rank-sum test.
GP IIb/IIIa = glycoprotein IIb/IIIa receptor antagonist; LAD = left anterior descending artery; LCX = circumflex coronary artery; PCI = percutaneous coronary intervention; RCA = right coronary artery; TR = transradial.

Table 3. Post-PCI Outcomes

	TR-All (n = 2,100)	TR-Success (n = 2,002)	TR-Failure (n = 98)	p Value
Clinical outcomes				
Emergency CABG	2 (0.1)	2 (0.1)	0	NS
In hospital death	2 (0.1)	1 (0.05)	1 (1)	NS
CVA	1 (0.05)	1 (0.05)	0	NS
Transfusion	9 (0.4)	8 (0.4)	1 (1)	NS
Access site complications				
Major bleeding	6 (0.2)	5 (0.2)	1 (1)	NS
Hematoma	16 (0.7)	15 (0.7)	1 (1)	NS
Vascular surgery	0	0	0	NS
Any vascular complication	22 (1)	20 (1)	2 (2)	NS

All values are n (%).
CVA = cerebrovascular accident; other abbreviations as in Table 1.

with the TR-PCI success group (1.2 ± 0.6 vs. 1.6 ± 1.0, $p < 0.0001$ for LCA; and 1.2 ± 0.6 vs. 1.4 ± 0.6, p = 0.003 for RCA, respectively). The number of stents used/patient was significantly greater in the TR-PCI failure group (1.8 ± 1 vs. 1.6 ± 1, p = 0.03). The TR-PCI failure group experienced significantly longer fluoroscopy time (13 [4 to 89] min vs. 11 [2 to 91] min, p = 0.01, data shown as median [range]) and higher contrast media use (205 [75 to 820] ml vs. 170 [10 to 820] ml, p = 0.0006, data shown as median [range]) compared with the TR-PCI success group.

Post-PCI clinical outcomes. Clinical outcomes of the study cohort are described in Table 3. Two patients died after PCI during their hospital stay. Both patients had developed cardiogenic shock after presenting with acute coronary syndrome. One patient suffered a cerebrovascular accident immediately after TR-PCI and was successfully thrombolysed with complete neurological recovery before discharge. Access site bleeding occurred in 6 (0.2%) patients, and access site hematoma developed in 16 (0.7%) patients requiring prolonged use of a radial clamp. No cases of symptomatic radial artery occlusion were identified. Nine (0.4%) patients received a blood transfusion. Six patients had developed an upper or lower gastrointestinal bleeding after PCI, and 3 patients had hemoglobin levels that dropped below 90 g/l without an obvious source of bleeding. No transfusion was required due to an access site vascular complication.

Mechanism and predictors of TR-PCI failure. The predominant mechanisms of TR-PCI failure were inability to advance the guide catheter to the ascending aorta in 50 patients (51%), poor guide catheter back-up support in 35 patients (36%), and unsuccessful arterial puncture in 13 (13%) patients (Table 4, Fig. 1). The guide catheter could not be advanced to the ascending aorta due to radial artery spasm impeding catheter manipulation or causing significant patient discomfort in 33 (34%) patients. Other causes of inability to advance guide catheter to ascending aorta included guidewire, sheath, or catheter-induced radial artery dissection in 10 (10%) patients, radial artery loop or tortuosity that could not be straightened with a 180-cm hydrophilic wire (Terumo Medical Corp., Somerset, New Jersey) in 6 (6%) patients, and radial artery stenosis with failure to advance guide catheter in 1 patient. Transradial approach PCI could not be completed in another 35 (36%) patients due to inadequate coronary cannulation or guide catheter back-up support, necessitating a switch to TF. Significant tortuosity of the subclavian artery was identified as a cause in 18 (18%) patients, whereas another 17 (17%) patients demonstrated no obvious abnormality of great vessel anatomy. The TR-PCI failure in these patients was attributed to calcification, tortuosity, and other features of the coronary anatomy that prevented successful delivery of stents and balloons to the target coronary segment with TR. The maximum number of guide catheters used by the operator before switching to TF was 6 for RCA and 7 guides for LCA. The TR-PCI failed due to unsuccessful arterial puncture in 13 (13%) patients in whom a radial sheath could not be placed after initial clinical assessment suggested suitability for TR-PCI.

The univariate predictors of TR-PCI failure included age ≥75 years (odds ratio [OR]: 4.41; 95% CI: 2.73 to 7.12, $p < 0.0001$), female sex (OR: 1.84; 95% CI: 1.15 to 2.92, p = 0.01), prior CABG (OR: 4.65; 95% CI: 2.34 to 9.21, $p < 0.0001$), and patient height (OR: 0.96; 95% CI: 0.94 to 0.98, p = 0.001). Body mass index >25 kg/m^2, prior PCI, and presentation with an acute coronary syndrome were not predictive of TR-PCI failure. On multivariate analysis, age ≥75 years (OR: 3.86; 95% CI: 2.33 to 6.40, p = 0.0006), prior CABG (OR: 7.47; 95% CI: 3.45 to 16.19, p = 0.0002), and height (OR: 0.97; 95% CI: 0.95 to 0.99, p = 0.02) were independent predictors of TR-PCI failure (Fig. 2); the association between short stature and TR-PCI failure remained significant after adjustment for other covariates and was most evident between the lowest and highest quartiles (OR: 2.55; 95% CI: 1.22 to 5.32, p = 0.002) (Figs. 2 and 3). Age >75 years (p = 0.04), male sex (p = 0.007), and multivessel PCI ($p < 0.0001$) were

Table 4. Mechanism and Causes of Transradial PCI Failure (n = 98)

Failure of arterial access	
Inadequate arterial puncture	13 (13)
Failure to advance catheter to ascending aorta	
Radial artery spasm	33 (34)
Radial artery dissection	10 (10)
Radial artery loop/tortuosity	6 (6)
Radial artery stenosis	1 (1)
Failure to complete PCI due to lack of guide support	
Subclavian tortuosity	18 (18)
Inadequate guide backup support	17 (17)

Values are n (%).
PCI = percutaneous coronary intervention.

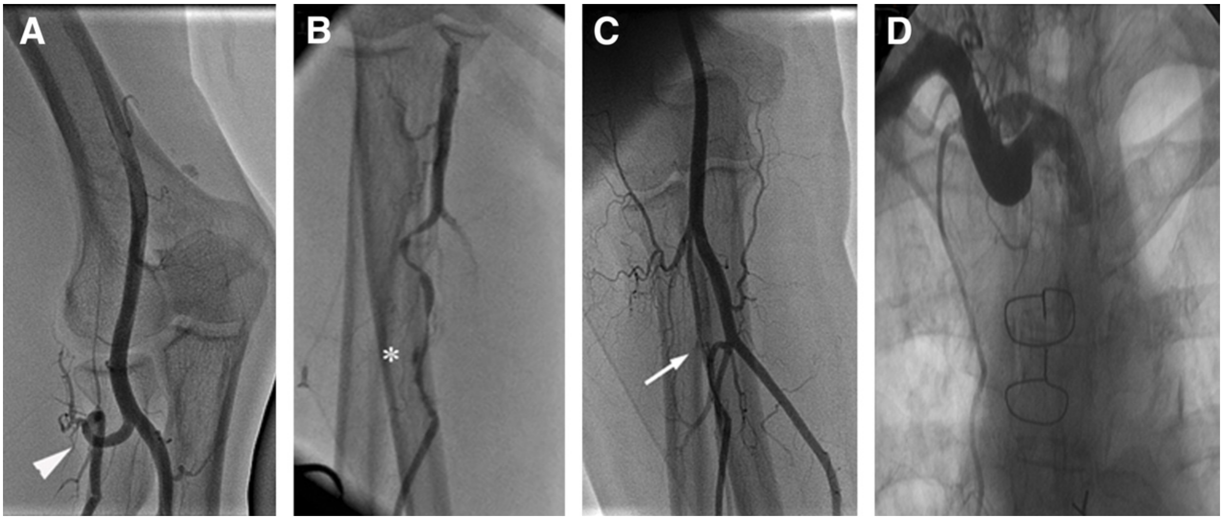

Figure 1. Causes of Transradial Approach Percutaneous Coronary Intervention Failure

(A) Radial artery loop **(arrowhead)**. **(B)** Guidewire-induced dissection **(*)**. **(C)** Severe spasm not relieved by intra-arterial nitroglycerin and verapamil **(arrow)**. **(D)** Severe subclavian tortuosity.

independent predictors of prolonged fluoroscopy time; male sex ($p < 0.0001$) and multivessel PCI ($p < 0.0001$) were independent predictors of increased contrast volume use (Online Appendix).

Discussion

The findings from the present study show that TR-PCI can be performed with a low (<5%) failure rate in a contemporary practice by low-to-intermediate volume TR operators with standard radial sheaths and traditional TF guide catheters. In patients with failed TR, PCI was successfully completed in a majority (96%) by switching to TF during the same procedure. The predominant mechanism of TR-PCI failure was inability to advance guide catheters to ascending aorta in 51%, inadequate guide catheter support for successful completion of PCI in 36%, and inability to obtain arterial access in 13% of patients. Advanced age, short stature, and prior CABG were independent predictors of TR-PCI failure.

Arterial access site bleeding and vascular complications are the most common adverse events associated with PCI procedures (15,16) and significant predictors of 1-year mortality (15,17). Multiple recent studies (18,19) have demonstrated a strong relationship between major bleeding and increased risk of death and ischemic events in patients undergoing PCI. Furthermore, a reduction in major bleeding in high-risk patients has been shown to decrease mortality and adverse clinical events (20,21).

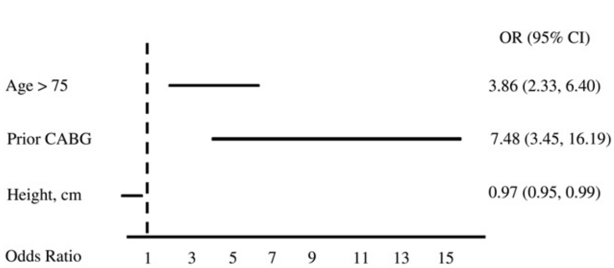

Figure 2. Multivariate Predictors of TR-PCI Failure

Age and prior coronary artery bypass graft surgery (CABG) were positive predictors and height was a negative predictor of transradial approach percutaneous coronary intervention (TR-PCI) failure. CI = confidence interval; OR = odds ratio.

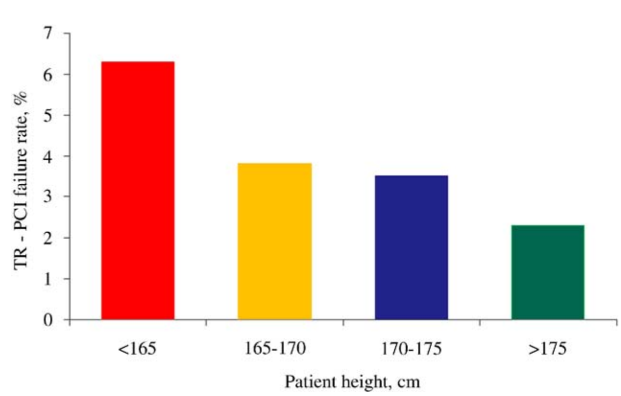

Figure 3. TR-PCI Failure Stratified by Patient Height

Data shown as quartiles. The transradial approach percutaneous coronary intervention (TR-PCI) failure rate was highest in patients with height <165 cm and lowest in patients with height >175 cm.

A significant reduction of vascular complications and access site bleeding with TR-PCI has been demonstrated in multiple small randomized trials and meta-analysis (4,10,22–24). This reduced rate of bleeding with TR-PCI has also been suggested to confer long-term mortality benefit in observational studies (25,26). However, despite these advantages, TR-PCI is employed in <2% of all cases in the U.S. (1) and <12% of total PCI volume internationally (26). The reasons for this underuse of TR-PCI have not been investigated but potentially include concerns over technical challenges of TR, lack of experience with use of specially designed radial guide catheters, and perceived mitigation of clinical benefit in a diverse patient population. In addition, most TR-PCI studies were performed by high-volume TR operators at centers with significant use of TR, employing specialized radial sheaths and specifically designed diagnostic and PCI guide catheters. Such reporting bias might also lead to reservations about generalization of results in low-to-intermediate volume TR-PCI operators.

To our knowledge, the present study is the largest registry of TR-PCI reporting on the mechanism and predictors of TR-PCI failure. Although TR-PCI was performed in only 38% of total PCI case volume during the study period, TR-PCI failure rate remained at <5% with an overall procedural success rate of >99%. These results are comparable to previously published reports of TR-PCI at high-volume transradial centers (4,9,10,24). Among patients with failed TR-PCI, the mechanism of failure was related to anatomic and technical factors resulting in an inability to advance the guide catheter to the ascending aorta, lack of adequate guide catheter back-up support, and inability to obtain adequate arterial access.

The main causes of the first mechanism of TR-PCI failure included radial artery stenosis, spasm, dissection, and radial loops or tortuosity. This is consistent with previous reports using 6-F sheaths and catheters (27). Several techniques with long hydrophilic guidewires and special catheters have been described to manage radial and brachial artery loops or tortuosity (9,28). However, they are frequently associated with significant patient discomfort and risk of arterial injury in our experience. Use of 5-F guide catheters reduces the incidence of spasm but might present difficulties with adequate guide catheter support in certain patients (29). Subclavian tortuosity and unfavorable anatomy of aortic root or coronary artery were predominant factors responsible for the second mechanism of TR-PCI failure and resulted in inadequate coronary cannulation or guide catheter back-up support. The true number of cases in which a PCI could not be completed due to this mechanism might be underestimated in this study, because of inability to advance the guide catheter to the ascending aorta in 50 patients. Subclavian tortuosity is observed in up to 11% of patients undergoing TR procedures (30) and might offer significant challenges for coronary cannulation or adequate guide catheter stability for delivery of angioplasty balloons and stents in tortuous and calcified coronary arteries. Diagnostic angiography might be accomplished in many patients with significant subclavian tortuosity with long hydrophilic followed by a stiff guidewire with additional support of a multipurpose catheter if needed. However, PCI in these select cases requires careful risk assessment due to increased risk of injury or thromboembolism, and switching to TF should be considered. In patients with no obvious abnormality of great vessels, TR-PCI might still be challenging due to poor guide catheter back-up support as a result of coronary calcification, tortuosity, and other features of coronary anatomy preventing successful delivery of stents and balloons to target coronary segments, a finding noted in 17% of TR-PCI failures in the present study. Use of extra support or multiple coronary guidewires, a 5-F catheter with deep intubation of coronary artery, or telescoping guides might be helpful, but switching to TF is advised to prevent excessive contrast and radiation exposure for both patient and the operator. The third mechanism of TR-PCI failure in this study related to unsuccessful arterial puncture, when a radial sheath could not be placed despite a positive clinical assessment of suitability for TR-PCI. This failure rate is higher compared with previous reports (10) and is likely related to "non radialist" expertise of operators. In addition to increased operator experience, use of specifically designed radial equipment such as 21-gauge needle, a 0.018-inch guidewire, and hydrophilic coated sheaths might further improve arterial access rates.

Age >75 years, prior CABG, and short stature were independent predictors of TR-PCI failure on multivariate analysis. Elderly persons constitute a growing segment of the patient population undergoing PCI and are at higher risk of periprocedural complications compared with their younger counterparts (31). The challenges of TR-PCI in elderly patients include advanced vascular disease with an accompanying increased tortuosity of subclavian artery and aortic arch. In addition, aortic root dilation, calcification, and diffuse atherosclerosis of both great vessels and the coronary arteries might produce difficulty in catheter manipulation and delivery of balloons and stents in elderly patients. The decrease in vascular complications with TR (2,23) needs to be carefully balanced against increased TR-PCI failure rate, higher radiation exposure, and greater contrast volume in this high-risk population. Prior CABG was also an independent predictor of TR-PCI failure, a finding likely related to the presence of hypertension and advanced atherosclerosis with resultant changes in great vessel anatomy similar to that seen with advanced age. We found short stature to be an independent predictor of TR-PCI failure. This association was present despite adjustment for BMI and female sex. Patients with height <165 cm were 2.5 times more likely to have TR-PCI failure compared with patients of height >175 cm (Fig. 2). This is likely related to a smaller size of radial artery and increased subclavian tortuosity in patients with short stature (30). In addition, patients with short stature are more likely to have a small aortic root and a short ascending aorta, preventing steady guide catheter coronary cannulation during TR-PCI. Specifically designed radial guide catheters might improve guide catheter performance in these patients at high risk of TR-PCI failure (32,33).

Study limitations. The main limitations of the present study include a single-center experience, low female representation in the study cohort, nonrandomized study design, and potential for selection bias in TR-PCI.

Conclusions

TR-PCI can be successfully performed by low-to-intermediate volume TR operators with standard equipment and traditional low-cost TF guide catheters with a low failure rate. Age >75 years, short stature, and prior CABG are independent predictors of TR-PCI failure. Appropriate patient selection and careful risk assessment are needed to maximize potential benefits offered by TR-PCI.

Reprint requests and correspondence: Dr. Asim N. Cheema, Division of Cardiology, St. Michael's Hospital, 30 Bond Street, Toronto, Ontario M5B 1W8, Canada. Email: cheemaa@smh.toronto.on.ca

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Key Words: coronary intervention ■ radial artery ■ vascular access.

APPENDIX

For supplementary data, please see the online version of this article.