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VASCULAR ACCESS

A Comparative Study of Transulnar and Transradial Artery Access for Percutaneous Coronary Intervention in Patients with Acute Coronary Syndrome

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***Objectives**: Transradial access has become commonly used for elective evaluation of patients with coronary artery disease, but it has some disadvantages and has had limited use in the acute coronary syndrome (ACS). Because the diameter of the ulnar artery is usually larger than that of the radial artery, we hypothesized that the ulnar artery could be used as an access for percutaneous coronary intervention (PCI). The present study compares the feasibility, safety, and outcome of transulnar artery and transradial artery access for PCI in patients with ACS.*
***Methods**: We reviewed 636 patients who had PCI for ACS from May 2006 to May 2009. The patients were randomly assigned to transulnar intervention (TUI; 317) or transradial intervention (TRI; 319).*
***Results**: Several outcomes were similar in the TUI and TRI groups: success rate of first puncture, duration of guiding catheter engagement, puncture-to-balloon inflation time, final thrombolysis in myocardial grade 3 flow, complications at the vascular access site, and postprocedure complications. The incidence of severe arterial spasm and forearm hematoma in the TUI groups was significantly less than that in the TRI group. At 1-year follow-up, the level of blood oxygen saturation at the middle finger and Doppler ultrasonographic characteristics of the ulnar artery did not significantly change from pre-PCI values for these criteria in either group.*
***Conclusion**: The TUI approach has results and access complications similar to the TRI approach and is a safe and feasible alternative for ACS patients.* (J Interven Cardiol 2014;27:525–530)

Introduction

The safety and effectiveness of transradial intervention (TRI) for coronary heart disease are well established. Compared with the femoral artery approach, TRI has fewer vascular complications at the access site, lower cost, and shorter hospital stay; it also is more comfortable for patients and allows them to ambulate sooner. Based on the results of recent studies, which found a low incidence of bleeding complications at the vascular access site;[1–3] it has been suggested that the transradial approach is a safe alternative to the femoral approach in the acute coronary syndrome (ACS), particularly when an aggressive anticoagulation/antiplatelet regimen is in effect.[4–6] However, use of TRI is limited by factors such as anatomic variations of the radial artery, vasospasm, inadequate blood supply to the hand via the palmer arch, and possible need of the artery for bypass grafts.[7,8] Because the diameter of the ulnar artery is larger than that of the radial artery, we questioned whether the ulnar artery could be used as an access for percutaneous coronary intervention (PCI) in patients with ACS. We have gained extensive experience in using transulnar intervention (TUI) since it was first reported by Fu et al.[9] in 2003. Although the safety and effectiveness of TUI for stable patients with coronary heart disease have been reported,[10,11] we have found no investigations for patients with ACS. We herein report a prospective, randomized study of the safety and feasibility of TUI and TRI for PCI in ACS patients. Particular attention

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was paid to the key issues of procedure-related major vascular bleeding, vascular complications, hand function disorder, and major adverse cardiac events (MACE) occurring within 1 year after TUI or TRI.

Methods

Study Population. From May 2007 to May 2009, of 1,281 consecutive patients admitted to our center for PCI, 636 (435 men, 201 women) were enrolled in the study. ACS was defined as any one of the following: (1) unstable angina pectoris; (2) ST segment elevation myocardial infarction; and (3) non-ST segment elevation myocardial infarction. Exclusion criteria were a negative Allen's test or reverse Allen's test (>10 seconds), nonpalpable right radial or ulnar artery, aortoarteritis, Raynaud's syndrome, forearm vascular fistula for dialysis, cardiogenic shock, and the need for a large guiding catheter. The patients were randomly assigned to the TUI group or the TRI group. Randomization was conducted in the admission room based on patients' year of birth: the TUI group included persons born in even years, and the TRI group included those born in odd years. The ethics committee of our hospital approved the study, which was performed according to the Good Clinical Practice standards and the principles of the Declaration of Helsinki and its subsequent amendments. All patients provided written informed consent before enrollment in the study.

Arterial Cannulation and Procedure. All procedures were performed by the same operator, who had extensive experience with the transradial and transulnar procedures (>3,000 diagnostic and therapeutic). Vascular evaluation by ultrasound and Allen's and reverse Allen's test was done before TUI to ensure that the patient had bilateral (radial and ulnar) blood supply to the hand. The radial or ulnar artery was punctured with a 21-G needle, and a 0.021-inch guidewire was inserted into the vessel; a 6F radial sheath (Cordis Transradial System, Cordis Corp., Bridgewater, NJ, USA) was introduced along the guidewire. A bolus of heparin (100 U/kg) and 200 μg of nitroglycerin were delivered through the sheath. Catheters (4F) were used for coronary angiography; a 6F guiding catheter was used for PCI. Heparin was given routinely, and all patients received a loading dose of aspirin (300 mg) and clopidogrel (150–300 mg) at admission; they also received aspirin (150 mg/day) and clopidogrel (75 mg/day) in the days preceding PCI. After PCI, they continued to take clopidogrel for 12 months and aspirin for their lifetimes. All patients were discharged with long-term statin therapy, unless side effects from the medication had occurred. Platelet glycoprotein IIb/IIIa receptor antagonists were administered for some high-risk patients in both groups according to the operator's preference. PCI success was defined as thrombolysis in myocardial infarction (TIMI) grade 3 flow and a decrease of stenosis to less than 20% of the original stenosis as determined with quantitative coronary analysis. The sheath was removed immediately after the procedure regardless of the level of anticoagulation, and a compression dressing was applied for 4–6 hours. We recorded the length of time it took for engagement of the guiding catheter, time from puncture to inflation of the balloon, and TIMI grade 3 flow of culprit vessel. For patients who switched over from to TUI to TRI or from TRI to TUI, vascular evaluation by ultrasound and Allen's and reverse Allen's test was done before the switching over to ensure that the patient had bilateral (radial and ulnar) blood supply to the hand.

Follow-Up. Before and 1 year after PCI the patients were evaluated with palpation of the radial and ulnar pulses, and by Allen's test or reverse Allen's test to evaluate blood supply to the hand. Complications of the procedure, including vascular occlusion, hematoma at the access site and forearm (diameter > 5 cm), arteriovenous fistula, pseudoaneurysm, and trauma of ulnar nerve, were recorded. The radial and ulnar arteries were examined with ultrasound (7.5 MHz VIVID 7, Chino, CA, USA), and blood oxygen saturation of the middle finger was measured with pulse oximetry (ASC-545, AK, Inc., USA) before and 1 year after PCI. Clinical follow-up was carried out by telephone or office visit for the entire year. MACE such as recurrence of angina, recurrence of MI, serious hemorrhage, and mortality were recorded.

Statistics Analysis. Continuous variables are expressed as the mean ± standard deviation, and the categorical variables are expressed as percentages. Continuous variables were compared by use of the t-test for normally distributed values; otherwise, the Mann–Whitney U-test was used. Proportions were compared by use of Fisher's exact test when the expected frequency was less than 5; otherwise, the chi-square test was used. P-values less than 0.05 (2-tailed) were considered statistically significant. Analysis was performed with the Statistical Package for Social Sciences, version 10.0, software (SPSS, Chicago, IL, USA).

Results

Clinical Characteristics of the Study Patients. Five patients in the TRI group were switched to the TUI group because of severe spasm of the radial artery; 6 patients in the TUI group were switched to the TRI group after several unsuccessful punctures (puncture time >5 minutes). The final TUI group included 317 patients, and the TRI group 319. There were no significant differences in demographic factors, cardiovascular status on admission, coronary heart disease risk factors, or location of MI between the 2 groups (Table 1). No patients in either group were rolled over to femoral access.

PCI Procedure Data. There were no significant differences in the success rate of first puncture, the duration of guiding catheter engagement, and puncture-to-balloon inflation time between the 2 groups (Table 2). Coronary artery stents were placed successfully in all patients. The rate of final TIMI grade 3 flow of culprit vessels was not different between the 2 groups (P = 0.54). Also, there was no significant difference in the amount of contrast medium used or in X-ray exposure time.

Vascular and Bleeding Complications and 1-Year MACE. Vascular and bleeding complications and 1-year MACE of the 2 groups were compared (Tables 3 and 4). There were no differences in the incidences of pseudoaneurysm, access site hematoma, or transfusion requirement between the 2 groups. The incidence of forearm hematoma and severe artery spasm in the TUI group was lower than in the TRI group (1.6% vs. 5.6%, P = 0.009; 0.9% vs. 5.0%, P = 0.006). Most instances of severe artery spasm in both groups were relieved after an injection of nitroglycerin. Although there were 35 cases of access site artery occlusion (6.3% in the TUI group and 4.7% in the TRI group, P = 0.357), no abnormal sensitivity or movement disability of the hands was found during the 1-year follow-up in patients of either group. The duration of hospital stay and 1-year MACE also were similar between the 2 groups. The time of Allen's test or reverse Allen's test and the level of blood oxygen saturation of the middle fingers did not change significantly from before the PCI to 1 year later in either group. Also, the Doppler ultrasound examination at the 1-year follow-up showed no significant changes from preprocedure values for the

Table 1. Clinical and Angiography Characteristics of the Patients

	TUI Group (n = 317)	TRI Group (n = 319)	P-Value
Male	219 (69.3%)	215 (67.3%)	0.648
Age (years)	58.6 ± 11.5	59.2 ± 11.4	0.511
Height (cm)	169.0 ± 6.3	168.0 ± 8.8	0.313
Weight (kg)	76.3 ± 7.3	76.0 ± 6.7	0.431
Hypertension	148 (46.8%)	143 (44.8%)	0.638
Diabetes mellitus	65 (20.5%)	62 (19.4%)	0.736
Hyperlipidemia	56 (17.7%)	59 (18.4%)	0.789
Smoking	155 (49.0%)	147 (46.0%)	0.477
Baseline serum creatinine	73.2 ± 16.8	72.5 ± 21.6	0.668
Clinical presentation			0.990
Unstable angina pectoris (n)	130 (41.1%)	135 (42.3%)	
NSTEMI (n)	110 (34.8%)	112 (35.1%)	
STEMI (n)	62 (19.6%)	65 (20.4%)	
New York Heart Association			
Heart function classification	1.8 ± 1.1	2.1 ± 1.3	0.156
Culprit vessel			0.848
Left anterior descending artery	144 (45.4%)	153 (48.0%)	
Right coronary artery	107 (33.9%)	105 (32.9%)	
Left circumflex artery	64 (20.2%)	60 (18.8%)	
Left main	2 (0.6%)	1 (0.3%)	
Multivessel disease	174 (55.0%)	185 (57.9%)	0.423
Pre-PCI TIMI flow grade			0.704
≤1	131 (41.5%)	137 (43.0%)	
≥2	185 (58.5%)	182 (57.0%)	

NSTEMI, non-ST elevated myocardial infarction; STEMI, ST-elevated myocardial infarction.

Table 2. Procedural Features

	TUI Group (n = 317)	TRI Group (n = 319)	P-Value
Guiding catheter engagement (minutes)	6.3 ± 1.3	5.9 ± 1.2	0.431
Puncture to balloon (minutes)	22.8 ± 22.7	20.3 ± 19.6	0.365
Successful rates of first puncture (%)	92.7%	95.9%	0.083
Post-PCI TIMI flow grade			0.266
3	278 (88.0%)	271 (85.0%)	
≤2	38 (12.0%)	48 (15.0%)	
Residual stenosis after the intervention (%)	5.9 ± 4.0	6.1 ± 2.7	0.347
Stents used per patient (n)	2.20 ± 0.57	2.30 ± 0.48	0.416
IIb/IIIa receptor antagonist (n)	47 (14.8%)	54 (16.9%)	0.469
Radiographic contrast amount (mL)	167.1 ± 35.2	156.1 ± 31.7	0.267
Exposure time (minutes)	13.9 ± 5.7	12.3 ± 4.9	0.253

Table 3. Vascular and Bleeding Complications, and 1-Year MACE

	TUI Group (n = 317)	TRI Group (n = 319)	P-Value
Pseudoaneurysm	0 (0%)	2 (0%)	0.482
Access site hematoma	8 (2.5%)	12 (3.7%)	0.371
Forearm hematoma	5 (1.6%)	18 (5.6%)	0.006
Major bleeding requiring transfusion	0 (0%)	0 (0%)	–
Severe artery spasm	3 (0.9%)	16 (5.0%)	0.003
Artery occlusion	20 (6.3%)	15 (4.7%)	0.374
Duration of hospital stay (days)	5.6 ± 2.5	5.8 ± 1.9	0.216
MACE	6 (1.9%)	8 (2.5%)	0.597

diameter of the access-site artery, systolic velocity, or resistance index of blood flow in either group.

Discussion

TRI has become a widely used approach for elective PCI.[12] The traditional femoral approach has more vascular complications than does the radial approach, especially in patients who need anticoagulants and full antiplatelet therapy. A recent meta-analysis found that transradial coronary intervention is effective and safe in the setting of ACS with respect to major bleeding as well as in MACE.[12,13] Transulnar cannulation has characteristics similar to those of the transradial approach, and a recent randomized trial suggested

Table 4. Comparison of Doppler Ultrasonography Parameters Between the 2 Groups

	Pre-PCI	1-Year Follow-Up	P-Value
TUI group (n = 317)			
Reverse Allen's test time (seconds)	2.70 ± 0.36	2.96 ± 0.98	0.126
Ulnar artery diameter (mm)	3.62 ± 0.28	3.33 ± 0.49	0.073
Systolic velocity (cm/s)	51.20 ± 6.23	45.60 ± 7.09	0.083
Resistance index	0.79 ± 0.05	0.84 ± 0.03	0.172
Finger oxygen saturation (%)	97.5 ± 10.6	96.0 ± 15.1	0.397
TRI group (n = 319)			
Allen's test time (seconds)	3.08 ± 0.52	3.22 ± 0.35	0.092
Radial artery diameter (mm)	3.26 ± 0.22	3.01 ± 0.48	0.066
Systolic velocity (cm/s)	50.30 ± 5.62	46.30 ± 6.91	0.102
Resistance index (RI)	0.80 ± 0.04	0.83 ± 0.06	0.096
Finger oxygen saturation (%)	98.2 ± 9.77	96.9 ± 10.1	0.112

that the procedures were equivalent.[10,11] However, the radial approach does not seem suitable for 5–15% of patients who will undergo cardiac catheterization. Reasons for the unsuitability include an abnormal Allen's test[14] and significant anatomic variations in the radial artery, such as loops, tortuous configurations, stenoses, hypoplasia, and aberrant origin.[15] Other causes, such as local scarring, synovial cysts, and local hematomas due to artery punctures for blood gas measurement, can preclude the use of the radial artery approach.

Because many patients with cardiovascular disease need more than 1 cardiac catheterization and about 5% will have a vascular occlusion after the transradial procedure,[16] the radial artery often cannot be used again as a bypass graft. In addition, a prior puncture of the radial artery may cause more intimal hyperplasia and reduced early graft patency. In an angiographic study, the deep palmar arch was complete in 99% of persons and the superficial palmar arch in only 40–80%.[17] The greater prevalence of radial collateral support than of ulnar collateral support suggests that ulnar cannulation may be preferable to radial cannulation, especially since the ulnar artery has a larger diameter and fewer α-receptors and is easier to palpate.[18] Transulnar access has a lower risk of vasospasm than does transradial access because vasospasm is related to vessel size and is mediated by the response of the α-receptors to epinephrine.[19,20] Because of these issues, we feel that priority should be given to preserving the radial vessel, and that the ulnar artery should be considered for use in PCI. Limbruno et al.[21] have reported positive results with primary angioplasty performed via transulnar access for acute myocardial infarction. Thus, we feel that TUI should be considered as an alternative for PCI in patients with ACS.

In this study, we had a high rate of successful ulnar cannulation, particularly when considering that the entry site was chosen at random in nonselected patients. The incidence of severe artery spasm in the TUI group was lower than in the TRI group, and as in the TRI group, the spasm was relieved after injection of nitroglycerin. Standard guiding catheters (6F) were used for the majority of the angioplasty procedures. No procedure that was performed through the right ulnar artery was associated with inadequate support of the guiding catheter, an outcome that was probably favored by several factors: The ulnar artery has a larger diameter and fewer α-receptors than the radial artery; the new, smaller diameter of a 4F (1.3 mm) catheter for coronary angiography was used to minimize the stimulation to the vascular wall before PCI; and effective drugs were used to prevent vascular spasm, in addition to reducing operation time and increasing the success rate of TUI. Entry-site complications also were less frequent with TUI than with TRI in our patients. We did not encounter trauma to the ulnar nerve, a serious potential complication of TUC, probably because we used a small-gauge needle carefully placed. The incidence of forearm hematoma in the TUI group was lower than in the TRI group, an outcome that may be due to less frequent reentry into the branch of the ulnar artery. The results of Doppler ultrasound examination at the 1-year post-PCI indicate that there were no significant changes in either group of patients in radial or ulnar artery diameter, blood peak flow velocity, and resistance from pre-PCI values. Low rates of MACE after coronary angioplasty were found for all patients, even though patients in both groups presented with ACS. It should be noted that the learning time for cardiac catheterization via the transulnar approach is longer than for the transfemoral approach.[22] In addition, constant practice is needed in order to sustain high success rates and few complications. The radial artery may be easier to cannulate than the ulnar artery because it is more superficial and thus easier to palpate at the wrist, even though it is smaller in diameter. However, hyperextension of the wrist often markedly facilitates perception of the ulnar pulse and cannulation of the vessel. Nonetheless, we can only recommend TUI for PCI if the operator has extensive experience with radial and ulnar access.

Study Limitations. Our study has limitations. It was a single-center trial, and the procedures were performed by only 1 operator, who was experienced in transradial and transulnar approaches. Since the radial and ulnar approaches require a longer learning curve than does the femoral approach, our results might not be reproducible by physicians untrained in the transradial technique. We also acknowledge that our patients were selected because we included only those who had a positive reverse Allen's test, thus assuring that they had adequate circulation to the hand.

Conclusion

The TUI approach, if performed by an experienced operator, has results and access complications similar

to the TRI approach. It is a safe and feasible alternative to TRI or femoral artery cannulation for ACS patients.

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