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Feasibility of the Radial Artery as a Vascular Access Route in Performing Primary Percutaneous Coronary Intervention

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We aimed to evaluate the feasibility of transradial primary percutaneous coronary intervention (PCI) in patients with ST elevation myocardial infarction (STEMI) by comparing the procedural results and complications with those of transfemoral intervention. From April 1997 to October 2004, we enrolled 352 consecutive cases of STEMI who underwent primary PCI. The femoral route was used in 132 cases (TFI group) and the radial route was used in 220 cases (TRI group). Cases with Killips class IV, a negative Allen test or a non-palpable radial artery were excluded from our study. Baseline clinical and angiographic profiles were comparable in both groups. Vascular access time was 3.8 ± 3.5 min in the TFI group and 3.6 ± 3.1 min in the TRI group, and cath room to reperfusion time was 25 ± 11 min in the TRI group and 26 ± 13 min in the TRI group. The procedural success rate was 89% in the TFI group and 88% in the TRI group. Crossover occurred in 9 cases (4%) due to approaching vessel tortuosity in the TRI group. Major access site complications occurred in 7 cases (5%) in the TFI group, and there were no complications in the TRI group ($p < 0.001$). Although radial occlusion occurred in 5 cases of the TRI group, there was no evidence of hand ischemia. The total hospital stay was significantly shorter in TRI group than in TFI group. In conclusion, use of the radial artery might be a potential vascular access route in performing primary PCI in selected cases.

Key Words: Angioplasty, transluminal, percutaneous coronary, radial artery, myocardial infarction

INTRODUCTION

The radial artery has primarily been used in cases when performing procedures via the femoral artery is difficult, such as prior aortic surgery, severe distal aortoiliac disease, or tortuosity.[1,2] Recently, there has been an increase in interest concerning the radial artery as a vascular access route for coronary procedures. The procedural results via the radial artery in elective percutaneous coronary interventional (PCI) cases were reported to be similar to those of transfemoral coronary intervention with a very low incidence of access site bleeding complications.[3-5]

In this era of potent antiplatelets and anticoagulants, primary PCI is associated with high access site bleeding complications during the typical transfemoral procedure.[6] There are relatively few reports regarding the feasibility and efficacy of primary PCIs performed via radial access in patients with ST elevation myocardial infarction (STEMI).[7-9]

Therefore, we aimed to evaluate the feasibility of the radial artery as a vascular route for primary PCI in STEMI by comparing the procedural results and local vascular complications.

MATERIALS AND METHODS

Study group

We retrospectively reviewed 391 patients with STEMI who underwent a primary PCI by three senior operators (greater than 200 PCI cases/year/operator) between April 1997 and October 2004. We included patients with STEMI who were treated within 12 hours of the onset of chest pain, and had available access to the radial and femoral

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approaches. The choice of access by either the femoral or radial artery was selected at the discretion of the operator.

Exclusion criteria were an absolute clinical indication to femoral approach due to cardiogenic shock in 25 cases (6.4%), a non-palpable radial artery in 5 cases (1.3%), negative Allen test in 3 cases (0.8 %), and a history of chronic renal failure in 6 cases (1.5%). The study group (total cases: 352) was comprised of 220 cases (62.5%) in the TRI group and 132 cases (37.5%) in the TFI group.

Pre-procedure preparation

When the diagnosis of STEMI was confirmed at the emergency department, all patients received baby aspirin (300 mg) and ticlopidine (500 mg) or clopidogrel (300 mg). A bolus of unfractionated heparin (70U/kg) or enoxaparin (30 mg) was injected intravenously in all cases. Written informed consent was obtained from the patient or family member(s) before the primary PCI.

In the cath room, the inguinal area was also prepared in the event that the radial approach failed. Therefore, it was necessary to have an IABP or the support of a temporary pacemaker in addition to preparation of the right or left wrist.

Transradial vs. transfemoral PCI procedures

The transradial PCI was performed via the left or right radial artery. To prepare for the procedure, the patients' arms were abducted and their wrists were hyperextended. After local subcutaneous infiltration with 2% lidocaine, radial artery puncture was performed with a 20-gauge angiocatheter needle (Sindongbang Co., Seoul, Korea) and either a 7 Fr MAXIMUM sheath (Daig Corp., Minnetonka, MN, USA) or a 6 Fr RADIFOCUS sheath (Termo Co., Tokyo, Japan) was put in place before the procedure depending on the lesion, the device needed for the procedure, and the radial artery size. After sheath insertion, 10 cc of a nitroglycerin cocktail (mixture of normal saline, 200 Ag of isosorbide dinitrate, 7.5 mg of lidocaine 1% and 100 Ag of verapamil) and a bolus of heparin (5000 IU for coronary angiography or 10,000 IU for intervention) were administered through the sheath. Coronary angiograms were performed using 4 Fr catheters and PCIs were performed with 6 or 7 Fr guide catheters. After the procedure, the arterial sheath was removed immediately, regardless of ACT level, and a compression dressing with gauze was applied for approximately 6 hours, or more, without the interruption of anticoagulants or antiplatelets.

In case of transfemoral PCI, the femoral artery was punctured with an 18-gauge arterial needle after local anesthesia with 2% lidocaine and a 6, 7 or 8 Fr arterial sheath was put in place. Coronary angiograms were performed using 5 Fr catheters and PCIs were performed 6, 7 or 8 Fr guide catheters. Hemostasis was achieved by manual compression and the arterial access sheaths were removed 4 to 6 hours after the procedure without the use of closure devices. Patients were allowed to ambulate in their rooms 16-24 hours after femoral sheath removal. After the coronary angiogram, primary PCIs were performed using the standard technique for the infarct-related artery.

Assessment of procedural results and complications

Endpoints were recorded from the start of the procedure to hospital discharge. Several time intervals were measured in our study: ER arrival time (time from symptom onset to the arrival at the ER); cath room arrival time (time from the ER arrival to the cath room arrival); vascular access time (time from lidocaine infiltration to installation of the arterial sheath); cath room to reperfusion time (time from the cath room arrival to the first balloon inflation); procedural time (time from the first attempt puncture the artery to the end of angioplasty); and ER to reperfusion time (time from the ER arrival to the first balloon inflation). We summed the time intervals in cases involving a switch in vascular access, such as TRI with crossover to TFI, or TFI with crossover to TRI.

Procedural success rate, major adverse cardiac events (MACE), hospital stay, and major access site bleeding were also assessed. Procedural success was defined as a residual diameter stenosis of < 30% with TIMI grade 3 flows. MACEs were defined as death, recurrent myocardial infarction, and target vessel revascularization up to 1 month after the procedure. Major access site bleeding was defined as a hemoglobin loss of at least 2 mmol/L, the administration of a blood transfusion, vascular repair, or prolonged hospitalization.

Data analysis

Statistical analysis was performed using the SPSS 11.0 statistical program (SPSS Inc., Chicago. IL, USA). Continuous variables were expressed as mean ± SD. Continuous variables were compared using the Student's t-test and the differences between categorical variables were examined using the chi-square test. A probability level of <0.05 was considered statistically significant.

RESULTS

Baseline patient characteristics

The baseline clinical characteristics of patients are shown in Table 1. Mean age, sex, and risk factors were similar in both groups. There were no statistical differences in Killips classification, left ventricular ejection fraction, infarct location, or ER arrival time between the femoral and radial approach groups.

There was no statistical difference in pre-procedural TIMI flow, reference vessel diameter, minimal luminal diameter (MLD), diameter stenosis of the lesion, or the extent of coronary artery disease. A culprit vessel of the right coronary artery was higher in TFI group than in TRI group (Table 1).

Table 1. Clinical and Angiographic Characteristics of the TRI and TFI Groups

	TRI group (N=220)	TFI group (N=132)
Age (yrs)	62 ± 12	64 ± 14
Male (%)	147 (67)	82 (66)
Hypertension (%)	84 (39)	63 (48)
DM (%)	57 (26)	41 (31)
Smoker (%)	128 (59)	71 (54)
Total cholesterol (mg/dl)	196 ± 38	190 ± 45
LVEF (%)	44 ± 13	44 ± 13
Killips class (%)		
I	137 (62)	70 (53)
II	44 (20)	38 (29)
III	39 (18)	24 (18)
Anterior wall MI (%)	121 (55)	62 (48)
Infarct related artery		
LAD (%)	120 (55)	62 (48)
LCX (%)	19 (8)	5 (4)
RCA (%)	80 (37)	65 (50)*
LMD (%)	1 (1)	0 (0)
Multivessel disease (%)	103 (47)	66 (50)
Pre-PCI TIMI 0 flow	162 (74)	98 (80)
Reference diameter (mm)	3.1 ± 0.5	3.3 ± 0.5
Pre-MLD (mm)	0.1 ± 0.2	0.1 ± 0.4
Pre-DS (%)	97 ± 0.7	97 ± 0.6

*p-value < 0.05.

TRI, transradial intervention; TFI, transfemoral intervention; LVEF, left ventricular ejection fraction; MI, myocardial infarction; LAD, left anterior descending; LCX, left circumflex; RCA, right coronary artery; LMD, left main disease; PCI, percutaneous coronary intervention; MLD, minimal luminal diameter; DS, diameter stenosis.

Time frame of patient triage and procedures

The mean times of ER to cath room arrival, cath room to reperfusion time, and ER to reperfusion time were similar in both groups (Table 2). Vascular access time was not significantly different between the two groups (TRI group: 3.6 ± 3.1 vs. TFI group: 3.8 ± 3.5 min; *p*=NS). Total procedure time of TRI was 43 ± 16 min which was similar that of TFI (47 ± 23 min; *p*=NS).

Procedural results

Vascular access

There was no case of puncture failure in either group. Nine cases (4.1%) in the TRI group required crossover to the femoral artery due to severe subclavian artery tortuosity in 3 cases (1.4%), the alpha loop of radial artery in 3 cases (1.4%), spasm with radial artery tortuosity in 1 case (0.5%), spasm with a too-small radial artery in 1 case (0.5%), and axillary artery tortuosity in 1 case (0.5%). The procedures were successfully completed after switching to the femoral artery.

Selection of guiding catheter and PCI outcomes

The size of the guiding catheter used for intervention in the femoral approach was 7 Fr in 57% of the cases, whereas 6 Fr guiding catheter was used in 77% of the cases in the radial approach group ($p<0.01$). Guiding catheters used for intervention were similar to those in engagement of the left coronary artery between the two groups. In approaching the right coronary artery, the Judkins right guiding catheter was used less in the TRI group than in the TFI group (TRI: 60%, TFI: 68%, $p<0.05$) Guiding catheters with a special curve were frequently used in the TRI group for approaching the right coronary artery (TRI: 25%, TFI: 15%, $p<0.05$).

Procedural success was achieved in 88% of the TRI group and 89% of the TFI group. Upon final coronary angiography, there were 4 cases of the "no reflow" phenomenon in the TRI group and 3 cases in the TFI group. Post-procedural MLD and diameter stenosis were similar in both groups. IABPs and temporary pacemakers were used more frequently in the TFI group than in the TRI group (Table 3). There was no significant difference in the frequency of stent implantation between the two groups (TRI group: 80% vs. TFI group: 83%; *p*=NS).

There were 8 cases of death in the TRI group (4%) and 9 cases in the TFI group (7%) (*p*=NS). In the TRI group, cardiac death occurred in 6 cases: 2 cases due to congestive heart failure, 2 cases due to ventricular fibrillation or tachycardia, and 2 cases due to free wall rupture and cardiac tamponade. Non-cardiac death occurred in 2 cases: 1 case of hemorrhagic shock on the site of IABP insertion, and 1 case of spontaneous hemorrhagic stroke at 3 days after hospital admission. In the TFI group, cardiac death occurred in 7 cases: 3 cases due to ventricular tachycardia or fibrillation, and 4 cases due to congestive heart failure. Non-cardiac death occurred in 2 cases: 1 case of hemorrhagic shock due to inguinal hematoma and 1 case of pneumonia with status asthmaticus (Table 4). There was no recurrent infarction or target vessel revascularization in either group.

Vascular complications

Major access site bleeding occurred in 7 cases (5%) in the TFI group: 5 cases of decreased hemoglobin requiring transfusion, 1 case of hemorrhagic shock due to inguinal hematoma, and 1

Table 2. Time Frame of Patient Triage and Procedures

	TRI group (N=220)	TFI group (N=132)
ER arrival time (min)	295 ± 281	252 ± 219
ER to cath room arrival (min)	59 ± 48	60 ± 44
Cath room to reperfusion (min)	26 ± 13	25 ± 11
Vascular access time (min)	3.6 ± 3.1	3.8 ± 3.5
Total procedure time (min)	43 ± 16	47 ± 23

**p*-value < 0.05.

TRI, transradial intervention; TFI, transfemoral intervention; ER, emergency room.

Table 3. Procedural Characteristics between the TRI and TFI Groups in Primary PCI

	TRI group (N=220)	TFI group (N=132)
Puncture failure (%)	0 (0)	0 (0)
Crossover (%)	9 (4.1)*	0 (0)
Size of guide catheter (%)		
6 Fr	169 (77)*	53 (40)
7 Fr	46 (21)	75 (57)*
8 Fr	5 (2)	4 (3)
Shape of guide catheter (%)		
LCA (N=207)		
JL	119 (85)	58 (87)
Amplatz	4 (4)	3 (5)
Special curve†	14 (10)	6 (9)
RCA (N=145)		
JR	48 (60)	44 (68)*
Amplatz	12 (15)	11 (17)
Special curve	20 (25)*	10 (15)
Balloon only/stent, (%)	17/83	20/80
IABP (%)	4 (2)	15 (11)*
Temporary pacemaker (%)	10 (5)	20 (15)*
Post-MLD (mm)	2.9 ± 0.6	3.0 ± 0.6
Post-DS (%)	10 ± 11	8 ± 12
Post-TIMI flow (%)		
0	4 (2)	3 (2)
1	2 (1)	2 (2)
2	19 (9)	10 (8)
3	195 (88)	117 (89)
Procedural success (%)	195 (88)	117 (89)

*p-value < 0.05.

PCI, percutaneous coronary intervention; TRI, transradial intervention; TFI, transfemoral intervention; LCA, left coronary artery; RCA, right coronary artery; JL, judkins left; JR, judkins right; † Special curve includes Kimny, Shani, XB, hockey stick and RAD guide catheters; IABP, intraaortic balloon pump; MLD, minimal luminal diameter; DS, diameter stenosis.

case that needed surgical evacuation and repair. There were no major access site complications in the TRI group ($p < 0.001$). The TFI group had a significantly greater number of hematomas than the TRI group (TFI: 11%, TRI: 1%, $p < 0.01$). Although radial occlusion occurred in 5 cases in the TRI group, there was no significant hand ischemia.

Hospital stay

The total hospital stay was significantly shorter in the TRI group than in the TFI group (TRI group: 5 ± 3 vs. TFI group: 8 ± 6 day; $p < 0.05$).

DISCUSSION

Procedural outcomes were similar in both groups and the time to reperfusion in the radial approach group was not a limiting step. Furthermore, vascular access site complications in the radial group were infrequent compared with the femoral approach. Based on our results, the radial artery might be a useful vascular access route in performing primary PCI in selected cases of acute myocardial infarction.

Regarding the use of the radial artery as a route for vascular access, we were concerned about an inability to successfully puncture the radial artery

Table 4. Clinical and Vascular Outcomes of the TRI and TFI Groups in Primary PCI

	TRI group (N=220)	TFI group (N=132)
In-hospital MACE (%)	8 (4)	9 (7)
Death	8 (4)	9 (7)
TVR	0 (0)	0 (0)
Reinfarction	0 (0)	0 (0)
Major bleeding Cx (%)	2 (1)	7 (5)*
Any vascular event (%)	7 (3)	16 (12)*
Local hematoma	2 (1)	15 (11)*
Pseudoaneurysm	0 (0)	1 (1)
Artery occlusion without ischemia	5 (2)	0 (0)
Hospital stay (days)	5.3 ± 2.6	8.4 ± 6.2*

*p-value < 0.05.
PCI, percutaneous coronary intervention; TRI, transradial intervention; TFI, transfemoral intervention; MACE, major adverse cardiac event; TVR, target vessel revascularization; Cx, complication.

and delayed reperfusion time due to a longer vascular access time (from lidocaine infiltration to arterial sheath insertion), and poor guiding support.

In fact, radial arterial access requires a learning period achieve competence.[10,11] Accessing the radial artery is technically more challenging and more time-consuming than the femoral access route. However, after mastering the skills for radial access, the technique is much easier and more reliable. In our study, there were no cases of puncture failure in the TRI group and no difference in vascular access time between the two groups. Therefore, radial arterial access may not be a limiting step in achieving reperfusion of the infarct-related artery.

Many interventional cardiologists are reluctant to use the radial artery due to its relatively small size and difficulty in guiding catheter support. In our study, the diameter of the radial artery in 1,488 cases of transradial diagnostic coronary angiographic study was 2.60 ± 0.41 mm.[12] When considering the size of the devices, such as the guiding catheter, balloon, and stent, the diameter of the radial artery was large enough to accommodate at least a 6 Fr guiding catheter in more than 93% of cases. Recently, there was an improvement in device technology that introduced a larger lumen guiding catheter and a low profile balloon catheter. Stents are even compatible with the 5Fr guiding catheter. In most cases in our study, there were no problems achieving good guiding support to complete the procedure.

In 9 cases (4.1%) of the TRI group, we had to switch to another access site in order to finish the procedure due to radial artery spasm and tortuosity of the conduit artery. Most of the problems (7 of 9 cases) presented early in the procedure and were less common later in the procedure. It was clear that this was a result of improvement in the operator's skill and the interventional devices, particularly the guide catheter.

Selection of the guide catheter was similar in the cannulation of left coronary artery (Table 3). In the case of cannulation for the right coronary artery, the Judkins right guiding catheter was used less in the TRI group compared with the TFI group. These differences the use of Judkins right catheters were probably due to the need for a guiding catheter with a special curve that could provide sufficient backup support when performing the procedure on the right coronary artery.

Complications of the vascular access site are frequently due to the usage of potent antiplatelets and anticoagulants in primary PCI.[13-15] Based on randomized placebo-controlled studies on performing primary PCI, ReoPro, a potent antiplatelet agent, had a significant effect in reducing death, reinfarction, and urgent revascularization. Moreover, ReoPro significantly reduced the rate for bailout stenting in the procedure.[13] However, concomitant use of ReoPro significantly increased the bleeding complications at the femoral arterial access site. Several methods are used to reduce access site complications, including closure devices, compression devices, and early sheath removal with temporary discontinuation of anticoagulants.[16-19] However, access site complications remain a problem in primary PCI. In this study, vascular complications rarely occurred in the TRI group. These results are consistent with previous studies that compared the vascular complications between the radial and femoral groups.[4,7,14] One study suggested that patients at a high risk for bleeding complications[15] (obesity, old age, facilitated PCI, and use of glycoprotein IIb/IIIa inhibitors etc.) are good candidates for the transradial approach in the case of primary PCI.

A temporary pacemaker was more frequently used in the TFI group as opposed to the TRI group. This was because the operator chose TFI in the event that a temporary pacemaker was needed during the PCI of the right coronary artery. Therefore, the IRA of RCA was more frequent in the TFI group. In addition, IABP was used more in the TFI than in the TRI group due to the frequent occurrence of transient shock in the TFI group during the procedure. During TRI, the IABP was inserted through the femoral artery in case that it was needed.

Although this study included a relatively large sample size of STEMI performed primary PCI (approximately 400 cases), an important limitation of this study is the retrospective observation and the lack of randomization between the radial and femoral groups. In addition, we excluded cardiogenic shock with STEMI from this study.

Several studies have shown that transradial access is an attractive option for approaching the vessel in elective coronary angiography and interventions due to lower access site complications, a shorter hospital stay, and increased patient comfort.[3-9] Our study revealed that the primary PCI for STEMI in an emergency setting has the same benefits and procedural results when performed by an experienced interventional cardiologists. In conclusion, the radial artery might be a potential vascular access route for performing primary PCI in selected cases.

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