Comparison of Clinical Outcomes between the Right and Left Radial Artery Approaches from the Korean Transradial Coronary Intervention Registry

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Purpose: Transradial intervention (TRI) shows anatomical and technical differences between the right radial approach (RRA) and left radial approach (LRA). The aim of this study was to evaluate the efficacy and safety using LRA, compared with RRA.

Materials and Methods: A total of 1653 consecutive patients who underwent TRI from November 2004 to October 2010 were enrolled in the Korean multicenter TRI registry. The patients were divided into two groups: the RRA group (n=792 patients) and the LRA group (n=861 patients). To adjust for any potential confounders, propensity score matched (PSM) analysis was performed (C-statistic: 0.726). After PSM, a total of 1100 patients were enrolled for analysis.

Results: After PSM, the RRA group exhibited a larger contrast volume (259.3±119.6 mL vs. 227.0±90.7 mL, p<0.001), a longer fluoroscopic time (22.5±28.0 minutes vs. 17.1±12.6 minutes) and higher access site change (12.3% vs. 1.0%, p<0.001) than the LRA group. Meanwhile, the LRA group showed a shorter procedure time (49.2±30.4 minutes vs. 55.4±28.7 minutes, p=0.003) than the RRA group. After PSM, in-hospital complications and 12-month cumulative clinical outcomes were similar between the two groups.

Conclusion: Of the two TRI methods, LRA was associated with better procedural efficacy, including shorter procedural time, smaller contrast volume, and less access site change than RRA. However, both methods showed similar 12-month cumulative clinical outcomes. Therefore, LRA was deemed superior to RRA in terms of procedural feasibility without a significant difference in clinical outcomes.

Key Words: Percutaneous coronary intervention, radial artery, treatment outcome

INTRODUCTION

The transradial intervention (TRI) has several advantages, such as reduction of bleeding risk, improvement of patients’ convenience, and immediate ambulation, as compared with transfemoral intervention (TFI). However, the TRI is associated with longer learning curve and increased fluoroscopy time, compared with TFI. In TRI, there are some anatomical and technical differences between the right radial approach (RRA) and the left radial approach (LRA). The aim of this study was to evaluate the impact of the choice of the RRA or the LRA on procedural and in hospital complications, as well as 12-month clinical outcomes, in patients undergoing TRI.
Study outcomes

We accessed clinical outcomes and safety outcomes at 12 months after the index procedure, which were determined before the registry was started. Clinical outcomes were major adverse cardiac events (MACE), composed of all-cause mortality, myocardial infarction (MI), target vessel revascularization (TVR), and stroke. All-cause mortality consisted of cardiac and noncardiac deaths. MI was defined as a creatine kinase

Table 1. Baseline Clinical Characteristics

| Variables, n (%) | Right (n=792) | Left (n=861) | Entire patients | Right (n=550) | Left (n=550) | After PSM patients |
|------------------|---------------|--------------|----------------|---------------|--------------|------------------|
| Male             |               |              | 0.001          |               |              |                  |
| Age, yrs         |               |              | 0.001          |               |              |                  |
| Systolic BP (mm Hg) |       |              | 0.001          |               |              |                  |
| Dystolic BP (mm Hg) |       |              | 0.001          |               |              |                  |
| Heart rate       |               |              | 0.001          |               |              |                  |
| LVEF (%)         |               |              | 0.001          |               |              |                  |
| Diagnosis        |               |              | 0.001          |               |              |                  |
| MI               |               |              | 0.001          |               |              |                  |
| NSTEMI           |               |              | 0.001          |               |              |                  |
| Stable angina    |               |              | 0.001          |               |              |                  |
| Unstable angina  |               |              | 0.001          |               |              |                  |
| Hypertension     |               |              | 0.001          |               |              |                  |
| Diabetes         |               |              | 0.001          |               |              |                  |
| Dyslipidemia     |               |              | 0.001          |               |              |                  |
| CVA              |               |              | 0.001          |               |              |                  |
| Heart failure    |               |              | 0.001          |               |              |                  |
| PAD              |               |              | 0.001          |               |              |                  |
| CKD              |               |              | 0.001          |               |              |                  |
| Dialysis         |               |              | 0.001          |               |              |                  |
| Smoking          |               |              | 0.001          |               |              |                  |
| Current smoking  |               |              | 0.001          |               |              |                  |
| Previous MI      |               |              | 0.001          |               |              |                  |
| Previous CABG    |               |              | 0.001          |               |              |                  |
| Previous PCI     |               |              | 0.001          |               |              |                  |
| Laboratory findings |         |              | 0.001          |               |              |                  |
| HbA1c            | 6.4±1.3       | 6.6±1.3      | 0.069          | 6.5±1.2       | 6.5±1.3      | 0.394            |
| CK-MB            | 21.5±94.3     | 14.8±61.3    | 0.101          | 23.9±108.7    | 15.0±69.9    | 0.118            |
| Troponin I       | 2.9±11.4      | 7.8±130.3    | 0.398          | 3.6±12.8      | 10.4±166.7   | 0.440            |
| Troponin T       | 0.2±1.4       | 0.2±1.2      | 0.546          | 0.2±1.5       | 0.2±1.0      | 0.837            |
| BNP (pg/mL)      | 323.3±875.2   | 211.0±604.2  | 0.026          | 326.1±840.3   | 173.4±553.0  | 0.010            |
| hs CRP (mg/dL)   | 1.6±8.3       | 1.9±11.5     | 0.497          | 1.4±9.2       | 2.1±14.2     | 0.374            |
| Creatinine (mg/dL) | 0.9±0.3       | 0.9±0.4      | 0.272          | 0.9±0.4       | 0.9±0.5      | 0.666            |

PSM, propensity score matched; BP, blood pressure; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NSTEMI, ST-segment elevation myocardial infarction; CK-MB, creatine kinase MB; BNP, B-type natriuretic peptide; hs CRP, high sensitivity C-reactive protein.

Continuous variables are given as the mean SD; categorical variables are given as counts, with percentages in parentheses.

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value of >three times the upper normal limit. TVR was defined as any repeated previous percutaneous coronary intervention (PCI) or bypass surgery of any segment of the target vessel. Stroke was defined as a clinical neurologic deficit from hemorrhagic or ischemic neurologic insult. The safety outcomes were based on the rate of major bleeding. Major bleeding was defined as one of the following: bleeding requiring transfusion of >2 units of packed cells or bleeding that was fatal. Fatal bleeding included the following: intracranial bleeding, one that brought about reduction in the hemoglobin level of >5 g/dL or led to substantial hypotension requiring the use of intravenous inotropic agents, one that required surgical intervention, or one that required transfusion of >4 units of packed cells. Vascular access related bleeding was defined as one that was related to surgical or procedural interventions, such as access artery dissection, perforation, arteriovenous fistula, pseudoaneurysm or local hematoma requiring transfusion.

Statistics
The covariates that were adjusted for exposure to approach artery included age, gender, hypertension, diabetes mellitus, dyslipidemia, smoking, previous MI, previous coronary artery bypass graft (CABG), PCI, chronic heart failure and previous cerebrovascular accidents (CVAs), chronic kidney disease, number of treated vessels, treated vessels [left descending artery, left circumflex, right coronary artery (RCA), left main, ramus], lesion characteristics (type B2 or C, bifurcation, diffuse, calcification), used drug-eluting stents type (sirolimus-eluting, paclitaxel-eluting, zotarolimus-eluting, everolimus-eluting), overlap stenting and in-hospital medication treatments (aspirin, clopidogrel, cilostazol, beta-blockers, angiotensin converting enzyme inhibitors or angiotensin II receptor blockers, and statins). The C-statistic for the logistic regression model that was used to calculate the propensity score matching for the two groups was 0.726. After PSM, the baseline covariates were compared between the two groups. Various clinical outcomes at 1 year were estimated with the Kaplan-Meier method, and differences between groups were compared with the log-rank test in the PSM patients.

Table 2. Baseline Angiographic and Procedural Characteristics

| Variables, n (%) | Entire patients | p value | After PSM patients | p value |
|------------------|----------------|---------|-------------------|---------|
|                  | Right (n=792)  | Left (n=861) |       | Right (n=550) | Left (n=550) |
| **Target lesion**|                |          |                   |         |
| LAD              | 457 (57.7)     | 484 (56.2) | 0.542            | 320 (58.1) | 304 (59.2) | 0.330 |
| LCx              | 129 (16.2)     | 174 (20.2) | 0.040            | 103 (18.7) | 106 (19.2) | 0.818 |
| RCA              | 369 (46.5)     | 398 (46.2) | 0.882            | 241 (43.8) | 251 (45.6) | 0.544 |
| Left main        | 23 (2.9)       | 40 (4.6)  | 0.065            | 18 (3.2)  | 22 (4.0)  | 0.519 |
| **Lesion characteristics** |            |          |                   |         |
| Type B2/C        | 590 (74.4)     | 602 (69.9) | 0.038            | 391 (71.0) | 389 (70.7) | 0.894 |
| Bifurcation      | 214 (27.0)     | 173 (20.0) | 0.001            | 123 (22.3) | 119 (21.6) | 0.771 |
| Diffuse (>2 cm)  | 307 (38.7)     | 310 (36.0) | 0.247            | 200 (36.3) | 204 (37.0) | 0.802 |
| Calcification    | 57 (7.1)       | 172 (19.9) | <0.001           | 53 (9.6)  | 56 (10.1) | 0.762 |
| Multivessel disease* | 185 (23.3) | 227 (26.3) | 0.158            | 129 (23.4) | 133 (24.1) | 0.777 |
| Chronic total occlusion | 51 (6.4) | 75 (8.7)  | 0.082            | 40 (7.2)  | 38 (6.9)  | 0.814 |
| **Stent type**   |                |          |                   |         |
| SES              | 74 (9.3)       | 84 (9.7)  | 0.776            | 56 (10.1) | 53 (9.6)  | 0.762 |
| PES              | 412 (52.0)     | 325 (37.7) | <0.001           | 235 (42.7) | 243 (44.1) | 0.627 |
| ZES              | 181 (22.8)     | 333 (38.6) | <0.001           | 164 (29.8) | 173 (31.4) | 0.556 |
| EES              | 293 (36.9)     | 322 (37.3) | 0.865            | 224 (40.7) | 212 (38.5) | 0.459 |
| **Procedural characteristics** |            |          |                   |         |
| Adjuvant ballooning | 599 (75.6) | 590 (68.5) | 0.001            | 398 (72.3) | 371 (67.4) | 0.076 |
| LMWH             | 194 (24.4)     | 167 (19.3) | 0.012            | 115 (20.9) | 111 (20.1) | 0.765 |
| GpIIb/IIIa inhibitor | 20 (2.5)    | 46 (5.3)  | 0.003            | 17 (3.0)  | 15 (2.7)  | 0.720 |
| Contrast volume (mL) | 268 ±119.7 | 228±92.3 | <0.001           | 258±119.6 | 227±90.7 | <0.001 |
| F-time (min)     | 21.5±26.1      | 17.0±12.4 | 0.004            | 22.5±28.0 | 17.1±12.6 | 0.005 |

PSM, propensity score matched; LAD, left anterior descending artery; LCx, left circumflex artery; RCA, right coronary artery; SES, sirolimus-eluting stent; PES, paclitaxel-eluting stent; ZES, zotarolimus-elution stent; EES, everolimus-elution stent; LMWH, low molecular weight heparin; GpIIb/IIIa inhibitor, glycoprotein IIb/IIIa inhibitors; F-time, fluoroscopic time.

Continuous variables are given as the mean SD; categorical variables are given as counts, with percentages in parentheses.

*Number of coronary arteries narrowed >2.
RESULTS

The baseline clinical characteristics of these patients are given in Table 1. After PSM, the baseline clinical characteristics were balanced between the two groups, except the RRA group had higher B-type natriuretic peptide (326.1±840.3 pg/mL vs. 173.4±553.0 pg/mL, p=0.010) (Table 1). The baseline angiographic and procedural characteristics are given in Table 2. After PSM, the baseline angiographic and procedural characteristics were balanced between the two groups, except the RRA group had larger contrast volume (259.3±119.6 mL vs. 227.0±90.7 mL, p<0.001) and longer fluoroscopic time (22.5±28.0 minutes vs. 17.1±12.6 minutes, p=0.005) during procedure, compared with the LRA group. The procedural and in-hospital complications are given in Table 3. After PSM, the RRA group had higher chance of access site change (12.3% vs. 1.0%, p<0.001) than the LRA group. However, procedural complications, including acute thrombosis, dissection, distal embolization, perforation, and side branch occlusion, were similar between the two groups. Access site complications, including hematoma, and in-hospital complication, including cardiogenic shock, acute renal failure, gastrointestinal bleeding, and contrast induced nephropathy, were similar between the two groups. The cumulative clinical outcomes up to 12 months are given in Table 4. After PSM, the cumulative clinical outcomes up to 12 months, including mortality, recurrent MI, repeat revascularization, stent thrombosis, and MACE, were similar between the two groups. However, the RRA group showed a numerically higher incidence of CVA than the LRA group, although the difference between the two groups did not reach statistical significance in-hospital (0.5% vs. 0.1%, p=0.624) and up to 12 months (1.1% vs. 0.2%, p=0.124).

DISCUSSION

The TRI has reduced risk of major bleeding, improved patient comfort and convenience, and reduce inpatient time and costs, compared with TFI.9,10 In TRI, there are clear differences in techniques, advantages, and disadvantages for the RRA and the LRA. The RRA allows for the operator to stand on the right side and has good backup force for left coronary artery. However, the RRA has poor back up force for the RCA, and it is not adequate for post CABG patients and subclavian artery tortuosity. The LRA is easy to negotiate around the arch and has good back up force for RCA. However, arm positioning of the LRA is challenging in some cases, such obese patients.11,12 A previous study reported that the LRA is associated with a shorter learning curve, compared to the RRA.11 In this study, we compared the baseline procedural characteristics between the RRA and the LRA groups using PSM analysis. RRA had larger contrast volume (259.3±119.6 mL vs. 227.0±90.7 mL, p<0.001) and longer

### Table 3. Procedural and In-Hospital Complications

| Variables, n (%) | Entire patients | p value | After PSM patients | p value |
|------------------|-----------------|---------|--------------------|---------|
|                  | Right (n=792)   | Left (n=861) |                   | Right (n=550) | Left (n=550) |       |
| Procedural complications | 65 (8.2)   | 88 (10.2) | 0.158             | 49 (8.9)   | 56 (10.5)    | 0.360 |
| Acute thrombosis   | 2 (0.2)      | 3 (0.3)   | 1.000             | 1 (0.1)    | 2 (0.3)      | 1.000 |
| Distal embolization | 2 (0.2)     | 1 (0.1)   | 0.610             | 2 (0.3)    | 0 (0.0)      | 0.500 |
| Perforation        | 3 (0.3)      | 1 (0.1)   | 0.355             | 1 (0.1)    | 1 (0.1)      | 1.000 |
| Side branch occlusion | 24 (3.0) | 42 (4.8)   | 0.055             | 19 (3.4)   | 30 (5.4)     | 0.108 |
| No reflow          | 20 (2.5)     | 20 (2.3)  | 0.789             | 18 (3.2)   | 10 (1.8)     | 0.126 |
| Access site complications |          |           |                   |           |               |       |
| Access site change | 80 (10.1)   | 10 (1.1)  | <0.001            | 68 (12.3)  | 6 (1.0)      | <0.001 |
| Hematoma           | 7 (0.8)      | 10 (1.1)  | 0.576             | 4 (0.7)    | 4 (0.7)      | 1.000 |
| Minor hematoma (<4 cm) | 7 (0.8) | 10 (1.1)  | 0.576             | 4 (0.7)    | 4 (0.7)      | 1.000 |
| Major hematoma (≥4 cm) | 0 (0.0)  | 0 (0.0)   | 1.000             | 0 (0.0)    | 0 (0.0)      | 1.000 |
| In-hospital complications |          |           |                   |           |               |       |
| Cardiogenic shock  | 20 (2.5)     | 19 (2.2)  | 0.670             | 15 (2.7)   | 12 (2.1)     | 0.559 |
| Acute renal failure | 0 (0.0)     | 4 (0.4)   | 0.126             | 0 (0.0)    | 4 (0.7)      | 0.124 |
| Acute heart failure | 9 (1.1)     | 9 (1.0)   | 0.859             | 6 (1.0)    | 6 (1.0)      | 1.000 |
| Cerebrovascular accident | 4 (0.5) | 2 (0.2)   | 0.435             | 3 (0.5)    | 1 (0.1)      | 0.624 |
| Gastrointestinal bleeding | 5 (0.6)  | 8 (0.9)   | 0.493             | 3 (0.5)    | 4 (0.7)      | 1.000 |
| Transfusion        | 29 (3.6)     | 41 (4.7)  | 0.267             | 17 (3.0)   | 27 (4.9)     | 0.124 |
| Transfusion (pint) | 43±7.6      | 23±1.8    | 0.172             | 4.5±9.7    | 2.2±2.0      | 0.358 |
| Contrast reaction  | 5 (0.6)      | 12 (1.3)  | 0.125             | 2 (0.3)    | 6 (1.0)      | 0.287 |
| Contrast induced nephropathy | 5 (0.6) | 11 (1.2)  | 0.180             | 2 (0.3)    | 5 (0.9)      | 0.452 |

PSM, propensity score matched.
Continuous variables are given as the mean SD; categorical variables are given as counts, with percentages in parentheses.

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fluoroscopic time (22.5±28.0 minutes vs. 17.1±12.6 minutes, p=0.005) during the procedure, compared with LRA.

In this study, the RRA group had higher chance of access site change (12.3% vs. 1.0%, p<0.001), which seems to be due to difficulty in catheter manipulation, which is particularly troublesome for operators with less experience. However, procedural complications, including acute thrombosis, dissection, distal embolization, perforation, and side branch occlusion, were similar between the two groups. Also access site complications, including hematoma, and in-hospital complication, including cardiogenic shock, acute renal failure, gastrointestinal bleeding, and contrast induced nephropathy, were similar between the two groups. Therefore, we suggest that although RRA had larger contrast volume and longer fluoroscopic time during procedure, compared with LRA, both are safe and effective treatments.

In this study, after PSM, the mortality, recurrent MI, repeat revascularization, stent thrombosis, and MACE, were similar between the two groups. However, although the incidence of CVA (stroke and transient ischemic attacks) was numerically higher in the RRA group, compared to the LRA group, it was not statistically significant in-hospital (0.5% vs. 0.1%, p=0.624) and up to 12 months (1.1% vs. 0.2%, p=0.124).

In RRA, catheters have to pass the opening of the right brachiocephalic artery and bend sharply into the ascending aorta, which may disrupt atherosclerotic plaques with subsequent embolization.\textsuperscript{13} Also, the longer duration of angiography with RRA contribute an additional embolic source, compared with LRA.\textsuperscript{13,14} Stroke event rates in the general population were 0.4%, and similar results have also been obtained in previous studies where the trans-femoral approach was used: Fuchs, et al.\textsuperscript{15} reported that stroke event rate of 0.38%. A similar stroke rate was observed in the reports from Emory University (0.05–0.38%).\textsuperscript{16} and the Cleveland Clinic (0.3%).\textsuperscript{17} Lund, et al.\textsuperscript{18} reported that TRI generated significantly more particulate microemboli than TFI. Therefore, in the present study, we suggest that the choice of the LRA may be helpful to reduce the incidence of CVA during TRI.

The present study has several limitations. First, the present study was an observational study and was multicenter based retrospective in design. Because of the design of this study, a cause-result relationship was not established. Second, because

### Table 4. Cumulative Clinical Outcomes Up to 12 Months

| Variables                  | Entire patients | p value | After PSM patients | p value |
|----------------------------|-----------------|---------|--------------------|---------|
|                            | Right (n=792)   | Left (n=661) |       | Right (n=550) | Left (n=550) |
| Total death                | 22 (2.7)        | 29 (3.3) | 0.488             | 14 (2.5) | 12 (2.1) | 0.691 |
| Cardiac death              | 21 (2.6)        | 25 (2.9) | 0.756             | 14 (2.5) | 11 (2.0) | 0.544 |
| Non-cardiac death          | 1 (0.1)         | 4 (0.4)  | 0.376             | 0 (0.0)  | 1 (0.1)  | 1.000 |
| Recurrent MI               | 1 (0.1)         | 1 (0.1)  | 1.000             | 1 (0.1)  | 1 (0.1)  | 1.000 |
| NSTEMI                     | 1 (0.1)         | 1 (0.1)  | 1.000             | 1 (0.1)  | 1 (0.1)  | 1.000 |
| Revascularizations         | 6 (0.7)         | 5 (0.5)  | 0.659             | 5 (0.9)  | 3 (0.5)  | 0.726 |
| TVR                        | 6 (0.7)         | 5 (0.5)  | 0.659             | 5 (0.9)  | 3 (0.5)  | 0.726 |
| Stent thrombosis           | 6 (0.7)         | 6 (0.6)  | 0.885             | 5 (0.9)  | 3 (0.5)  | 0.726 |

Outcomes at 12 months:

| Total death                | 31 (3.9)        | 52 (6.0) | 0.048             | 21 (3.8) | 26 (4.7) | 0.456 |
| Cardiac death              | 23 (2.9)        | 36 (4.2) | 0.162             | 15 (2.8) | 16 (2.9) | 0.855 |
| Non-cardiac death          | 8 (1.0)         | 16 (1.8) | 0.150             | 6 (1.0)  | 10 (1.8) | 0.314 |
| Recurrent MI               | 3 (0.3)         | 5 (0.5)  | 0.728             | 3 (0.5)  | 3 (0.5)  | 1.000 |
| STEMI                      | 0 (0.0)         | 1 (0.1)  | 1.000             | 0 (0.0)  | 1 (0.1)  | 1.000 |
| NSTEMI                     | 3 (0.3)         | 4 (0.4)  | 1.000             | 3 (0.5)  | 2 (0.4)  | 1.000 |
| Revascularizations         | 33 (4.1)        | 46 (5.3) | 0.263             | 25 (4.5) | 27 (4.9) | 0.776 |
| TVR                        | 33 (4.1)        | 43 (4.9) | 0.422             | 25 (4.5) | 27 (4.9) | 0.776 |
| Stent thrombosis           | 6 (0.7)         | 7 (0.8)  | 0.899             | 5 (0.9)  | 3 (0.5)  | 0.726 |
| CVA                        | 9 (1.1)         | 2 (0.2)  | 0.024             | 6 (1.1)  | 1 (0.2)  | 0.124 |
| MACE                       | 61 (7.7)        | 97 (11.2)| 0.014             | 44 (8.0) | 53 (9.6) | 0.339 |
| MACCE                      | 70 (8.8)        | 97 (11.2)| 0.102             | 50 (9.1) | 53 (9.6) | 0.756 |

PSM, propensity score matched; MI, myocardial infarction; STEMI, ST-segment elevation myocardial infarction; NSTEMI, non ST-segment elevation myocardial infarction; TLR, target lesion revascularization; TVR, target vessel revascularization; CVA, cerebrovascular accident; MACE, major adverse cardiovascular events; MACCE, major adverse cerebrovascular events.

Continuous variables are given as the mean SD; categorical variables are given as counts, with percentages in parentheses.
this study was not randomized, the operator or center can act as a bias to analyze outcomes of this study. Procedure time, amount of contrast media, and even CVA complication rate could be quite different per operator or center. However, unfortunately, the distributions of RRA and LRA per center were not analyzed, and center or operator factor cannot be ruled out. Therefore, in a future study on the approaching method of PCI, center or operator factors must be mentioned.

In reality, there are some obstacles to performing LRA PCI, because it is difficult for operators to puncture the LRA from the right side of the patient, especially if the patient is obese. Further, the left arm should be abducted to the greatest possible extent towards the operator and placed on a comfortable support for operator’s convenience. Therefore, if a craterization room can be set up for operator to be standing on the left side of the patient, LRA could be considered much easier.

In conclusion, while procedural efficacy, including procedural time and contrast volume, were increased and vascular access site change was more frequent in RRA, the incidence of procedural, in-hospital complications, and cumulative clinical outcomes up to 12 months were similar between the two procedures. Therefore, we suggest that LRA seems to be more effective vascular access route than RRA for TRI, although the safety of the two is similar, at least for 12 months.

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