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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).[1] However, the TRI is associated with longer learning curve[2] and increased fluoroscopy time, compared with TFI.[3] In TRI, there are some anatomical and technical differences between the right radial approach (RRA) and the left radial approach (LRA).[4,5] 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.

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•The authors have no financial conflicts of interest.

MATERIALS AND METHODS

Study population

The Korean TRI registry was used for this retrospective, observational study. A total of 1653 consecutive patients of 12 cen-

ters were enrolled in this study between November 2004 to October 2010. Patients were divided into two groups: the RRA group (n=792 patients) and the LRA group (n=861 patients). Since the baseline characteristics between two groups were not matched due to adjust potential confounders, propensity score matched (PSM) analysis was performed using a logistic regression model. After PSM, a total of 1100 patients were enrolled for this analysis. Detailed data on demographics, medical history, coronary anatomy, procedural process, procedural events, pharmacotherapy, and clinical outcomes from the index procedure were collected using a standardized reporting form. This study received approval from each Institutional Review Board.[6]

Study outcomes

We accessed clinical outcomes and safety outcomes at 12 months after the index procedure, which were determined before the registry was started.[6] 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 (%)	Entire patients			After PSM patients		
	Right (n=792)	Left (n=861)	*p* value	Right (n=550)	Left (n=550)	*p* value
Male	538 (67.9)	519 (60.2)	0.001	363 (66)	347 (63)	0.313
Age, yrs	64.3±11.2	66.7±10.9	<0.001	65.1±11.2	65.2±10.7	0.872
Systolic BP (mm Hg)	126.6±21.2	128.4±18.9	0.109	127.5±21.1	127.7±18.3	0.852
Dystolic BP (mm Hg)	76.4±13.2	77.2±11.9	0.314	76.8±13.2	77.2±11.5	0.659
Heart rate	73.2±13.3	74.7±13.9	0.054	73.1±13.0	74.9±14.1	0.054
LVEF (%)	58.2±10.8	56.3±12.8	0.100	58.1±10.9	57.0±12.2	0.337
Diagnosis						
MI	246 (31.0)	252 (29.2)	0.428	166 (30.1)	155 (28.1)	0.466
STEMI	108 (13.6)	134 (15.5)	0.268	80 (14.5)	72 (13.0)	0.485
NSTEMI	138 (17.4)	118 (13.7)	0.037	86 (15.6)	83 (15.0)	0.802
Stable angina	170 (21.4)	201 (23.3)	0.360	124 (22.5)	130 (23.6)	0.668
Unstable angina	336 (42.4)	351 (40.7)	0.494	232 (42.1)	239 (43.4)	0.670
Hypertension	506 (63.8)	550 (63.8)	0.997	347 (63.0)	344 (62.5)	0.852
Diabetes	239 (30.1)	316 (36.7)	0.005	186 (33.8)	182 (33.0)	0.798
Dyslipidemia	241 (30.4)	254 (29.5)	0.68	149 (27.0)	146 (26.5)	0.838
CVA	46 (5.8)	56 (6.5)	0.557	38 (6.9)	28 (5.0)	0.204
Heart failure	32 (4.0)	24 (2.7)	0.160	17 (3.0)	18 (3.2)	0.864
PAD	11 (1.3)	10 (1.1)	0.680	10 (1.8)	8 (1.4)	0.635
CKD	17 (2.1)	31 (3.6)	0.079	16 (2.9)	16 (2.9)	1.000
Dialysis	7 (0.8)	5 (0.5)	0.468	7 (1.2)	5 (0.9)	0.562
Smoking	420 (53.0)	406 (47.1)	0.017	279 (50.7)	265 (48.1)	0.399
Current smoking	280 (35.3)	247 (28.6)	0.004	169 (30.7)	167 (30.3)	0.896
Previous MI	75 (9.4)	64 (7.4)	0.136	44 (8.0)	37 (6.7)	0.419
Previous CABG	6 (0.7)	1 (0.1)	0.060	0 (0.0)	1 (0.1)	1.000
Previous PCI	144 (18.1)	140 (16.2)	0.301	99 (18)	91 (16.5)	0.523
Laboratory findings						
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.	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; STEMI, ST-segment elevation myocardial infarction; NSTEMI, non ST-segment elevation myocardial infarction; CVA, cerebrovascular accident; PAD, peripheral artery disease; CKD, chronic kidney disease; CABG, coronary bypass graft; PCI, percutaneous coronary intervention; HbA1c, hemoglobin A1c; 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.[7] 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.[8] 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			After PSM patients		
	Right (n=792)	Left (n=861)	*p* value	Right (n=550)	Left (n=550)	*p* value
Target lesion						
LAD	457 (57.7)	484 (56.2)	0.542	320 (58.1)	304 (55.2)	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						
TypeB2/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)	268.3±119.7	228.4±92.3	<0.001	259.3±119.6	227.0±90.7	<0.001
F-time (min)	21.6±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			After PSM patients		
	Right (n=792)	Left (n=861)	*p* value	Right (n=550)	Left (n=550)	*p* value
Procedural complications	65 (8.2)	88 (10.2)	0.158	49 (8.9)	58 (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)	4.3±7.6	2.3±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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Table 4. Cumulative Clinical Outcomes Up to 12 Months

Variables, n (%)	Entire patients			After PSM patients		
	Right (n=792)	Left (n=861)	*p* value	Right (n=550)	Left (n=550)	*p* value
Outcomes at 30 days						
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
TLR	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
TLR	23 (2.9)	36 (4.1)	0.162	17 (3.0)	23 (4.1)	0.334
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.

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.[13] Also, the longer duration of angiography with RRA contribute an additional embolic source, compared with LRA.[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.[15] reported a stroke event rate of 0.38%. A similar stroke rate was observed in the reports from Emory University (0.05–0.38%)[16] and the Cleveland Clinic (0.3%).[17] Lund, et al.[14] 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

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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