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Safety and efficacy of using Judkins left 3.5 guiding catheters for transradial right coronary artery intervention

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Abstract. – **OBJECTIVE:** There is limited data about the use of a Judkins left (JL) 3.5 guiding catheter for routine transradial right coronary artery (RCA) percutaneous coronary intervention (PCI). This study investigated the safety and efficacy of JL3.5 for RCA PCI.

PATIENTS AND METHODS: Patients with acute coronary syndrome (ACS) who underwent transradial RCA PCI between November 2019 and November 2020 at the Second Hospital of Shandong University were included. The study retrospectively compared JL 3.5 *vs.* other routine guiding catheters (GCs), including Judkins right (JR) 4.0 and Amplatz (left). Logistic multivariable analysis was used to analyze the factors associated with transradial RCA PCI success rate, in-hospital complications, and extra support.

RESULTS: The study included 311 patients: 136 in the routine GC group and 175 in the JL 3.5 group. There were no significant differences between the two groups regarding in-hospital complications, extra support technics, or success. The multivariable analyses showed that coronary chronic total occlusion (CTO) was negatively associated with intervention success (OR = 0.06, 95% CI: 0.016-0.248, $p < 0.001$) but positively with extra support (OR = 8.74, 95% CI: 1.518-50.293, $p = 0.015$). Tortuosity was associated with extra support (OR = 16.50, 95% CI: 3.324-81.589, $p = 0.001$). In the JL 3.5 group, the left ventricular ejection fraction (OR = 1.11, 95% CI: 1.03-1.20, $p = 0.006$), CTO (OR = 0.07, 95% CI: 0.008-0.515, $p = 0.009$), and tortuosity (OR = 0.17, 95% CI: 0.03-0.95, $p = 0.043$) were independently associated with intervention success.

CONCLUSIONS: JL 3.5 appears to be as safe and effective as the JR 4.0 and Amplatz (left) catheters for RCA PCI. When using the JL 3.5 catheter for RCA PCI, heart function, CTO, and tortuosity should be considered.

Key Words:
Judkins left 3.5, Right coronary artery, Percutaneous coronary intervention, Transradial.

Introduction

Percutaneous coronary intervention (PCI) is the main revascularization method for acute coronary syndrome (ACS)[1]. The transradial approach has become commonly used because of better patient comfort and lower complication rates[1,2]. Still, selecting the appropriate guiding catheters (GCs) is crucial for PCI success. Indeed, the GCs should provide good backup support and allow coaxiality and manipulation to ensure the successful completion of PCI, especially for the right coronary artery (RCA)[3-5]. Indeed, the RCA shows great variability of the origin and proximal segment, posing a problem for cannulation using a coaxial GC[3-5]. In some cases, selecting and using the appropriate GC constitute the primary challenge for RCA PCI.

Because of its manipulation effectiveness and safety, the Judkins right (JR) 4.0 GC is a routine GC for RCA PCI. Still, the JR GC does not always provide excellent backup support when a dilatation catheter must traverse a lesion with severe calcification, tortuosity, or occlusion stenosis[6-8]. The Amplatz (left) GC can offer excellent backup because its tip can be "seated" in the RCA orifice or advanced into the proximal segment[6-8]. The most common GC used in left coronary artery intervention is Judkins left (JL) and the extra-backup (EBU or XB) catheter with extra backup[8], but Suresh and Neelam[9] proposed that the JL 3.5 GC could be used as a multifunctional GC for left and right coronary artery PCI. They suggested that the JL 3.5 GC can be used in severe tortuosity and abnormal origin of the RCA, with manipulation effectiveness and success rate similar to the Amplatz (left) GC, but their clinical evidence[9] was limited.

Currently, the most commonly used left and right coronary angiography catheter is the tiger

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(TIG) multifunctional GC[10]. In this clinical work, the JL 3.5 GC was found to have a shape similar to the JR when the hard end of a Teflon guidewire is inserted into the secondary curve of the JL 3.5 GC. Besides, the JL 3.5 GC resembles the TIG angiography catheter, with the Teflon guidewire protruding outside. When we tried to perform RCA PCI with a JL 3.5 GC, the JL 3.5 could give great backup support and coaxiality, and its supporting force was equivalent to the Amplatz (left) GC. Therefore, to validate whether the JL 3.5 GC could achieve the same success rate of RCA PCI as routine RCA GCs, this retrospective study aimed to examine the data from patients with RCA lesions who underwent PCI at one institution. It was hypothesized that the JL 3.5 GC could achieve a high success rate of RCA-PCI in a real-world setting.

Patients and Methods

Study Design and Patients

Patients with ACS who underwent RCA PCI between November 2019 and November 2020 at the Cardiology Department of the Second Hospital of Shandong University (Jinan Shandong, China) were included. The study was designed as a retrospective comparison of JL 3.5 *vs.* other routine GCs, including JR 4.0 and Amplatz (left), regarding the success rate of transradial RCA PCI. All procedures were performed according to the current international guidelines[1]. The study protocol was approved by the Ethics Committee of the Second Hospital of Shandong University (No. KYL-2021(LW)006). The requirement for individual consent was waived by the committee because of the retrospective nature of the study.

The inclusion criteria were 1) > 18 years, 2) diagnosis of ACS based on typical clinical symptoms, electrocardiographic changes, and positive (acute myocardial infarction) or negative (unstable angina) troponin I[11,12], 3) RCA lesion stenosis > 70%, 4) RCA PCI by the transradial approach, and 5) PCI using drug-eluting stents (DES), drug-coated balloon (DCB), or plain balloon angioplasty (PBA). The patients who underwent RCA PCI with the retrograde approach were excluded.

The GC was selected according to 1) the origin of the RCA, 2) the shape of the proximal part of the RCA, and 3) lesion characteristics. JR 4.0 was the usual GC for RCA. Amplatz or JL 3.5 was used if extra support was needed in some difficult lesions, including lesions with chronic total occlusion (CTO), moderate/severe tortuosity, or severe calcification.

Outcomes

The primary outcomes were the in-hospital complications, the need for extra support, and the success of the procedures for the routine GC or the JL 3.5 group. Procedural success was defined as completion of a PCI procedure with < 30% residual stenosis by angiography and thrombolysis in myocardial infarction (TIMI) flow grade 3 without major adverse cardiovascular events (MACEs) (e.g., death, myocardial infarction, stent thrombosis, or target vessel revascularization) during hospitalization[1]. Extra support technics included Guidezilla and anchor balloon. In-hospital complications included dissection, hematoma, side branch loss, main branch loss, no-reflow, and death during hospitalization.

Data Collection and Definitions

All data were collected from the patient's medical records. Three independent cardiologists assessed lesion characteristics and intervention details from recorded intervention files. Discrepancies were solved by discussion.

ACS included unstable angina pectoris, acute ST-elevated myocardial infarction (STEMI), and non-ST elevated myocardial infarction (NSTEMI)[13-15]. Coronary CTO was defined as coronary lesions with TIMI grade 0 flow for ≥ 3 months[16]. Angiographic calcification was assessed as mild (spots), moderate (≤ 50% of the lesion diameter), and severe (> 50% of the lesion diameter)[17,18]. Moderate proximal vessel tortuosity was defined as the presence of at least two bends of > 70° or one bend of > 90°, while severe tortuosity was defined as two bends of > 90° or one bend of > 120°[19]. The lesions were classified into type A, B, or C according to the American College of Cardiology/American Heart Association (ACC/AHA) lesion classification[20].

Statistical Analysis

Statistical analysis was performed using SPSS 20.0 (IBM Corp., Armonk, NY, USA). The continuous variables were tested for normal distribution using the Kolmogorov-Smirnov test. Normally distributed continuous variables were presented as mean ± standard deviations and analyzed using Student's *t*-test. Those with a skewed distribution were presented as medians (interquartile ranges) and analyzed using the Mann-Whitney

U test. Categorical variables were presented as numbers and percentages and analyzed using the Chi-square test or Fisher's exact test, as appropriate. Multivariable logistic regression analysis was performed to identify the independently associated factors [among left ventricular ejection fraction (LVEF), in-stent restenosis (ISR), CTO, and tortuosity], presented as odds ratios (ORs) with 95% confidence intervals (CIs). Two-sided p-values < 0.05 were considered statistically significant.

Results

Characteristics of the Patients

A total of 311 patients were included. The patients in the routine GC group (n = 136) were 63.9 ± 11.0 years of age, and those in the JL 3.5 group were 61.8 ± 10.6 years (n = 175). No significant differences in clinical characteristics were observed between the two groups (all $p > 0.05$) (Table I).

Lesion-Related Characteristics

The two groups did not differ significantly in terms of radial access, classification of coronary lesions, the takeoff of the RCA, calcification, CTO, or bifurcation technics (all $p > 0.05$). The proportions of 7F GC (2.9% *vs.* 0, $p = 0.036$) and ostial lesions (8.6% *vs.* 2.9%, $p = 0.032$) were higher in the routine GC group than in the JL 3.5 group. The proportion of moderate/severe tortuosity (37.1% *vs.* 14.0%, $p < 0.001$) and ISR (8.6% *vs.* 2.9%, $p = 0.032$) was higher in the JL 3.5 group than in the routine GC group. There were no statistically significant differences between the two groups regarding the procedure time (25.9 ± 15.7 *vs.* 24.7 ± 12.2 min, $p = 0.480$), contrast volume (130.3 ± 28.2 *vs.* 128.6 ± 29.8 mL, $p = 0.603$), or X-ray dose (567.3 ± 403.7 *vs.* 542.8 ± 382.4 mGy, $p = 0.588$) (Table II).

Procedural Outcomes and In-Hospital Complications

There were no significant differences in in-hospital complications (2.2% *vs.* 4.6%, $p = 0.211$), extra support technics (2.9% *vs.* 5.1%, $p = 0.252$), or success (97.1% *vs.* 93.7%, $p = 0.135$) between the routine GC and JL 3.5 groups (Table II). Table III presents the individual cases with complications or failure.

Table I. Characteristics of the patients.

Characteristics	Routine GC (n = 136)	JL 3.5 (n = 175)	*p*
Age (years), mean ± SD	63.9 ± 11.0	61.8 ± 10.6	0.44
Sex (male), n (%)	91 (66.9)	120 (68.6)	0.43
Smoking, n (%)	62 (45.6)	80 (45.7)	0.54
Hypertension, n (%)	84 (61.8)	105 (60.0)	0.08
Diabetes, n (%)	44 (32.4)	56 (32.0)	0.52
Family history, n (%)	21 (15.4)	21 (12.0)	0.24
Previous stroke, n (%)	18 (13.2)	21 (12.0)	0.44
Previous MI, n (%)	27 (19.9)	26 (14.9)	0.16
Previous PCI, n (%)	49 (36.0)	68 (38.9)	0.35
Renal dysfunction, n (%)	5 (3.7)	4 (2.3)	0.35
Diagnosis, n (%)			0.08
UA	88 (64.7)	98 (56.0)	
AMI	48 (35.3)	77 (44.0)	
LVEF (%), mean ± SD (n*)	58.4 ± 8.9 (135)	57.5 ± 7.8 (171)	0.20
LV-D (mm), mean ± SD (n*)	48.1 ± 5.3 (134)	48.6 ± 5.1 (171)	0.73
AAD (mm), mean ± SD (n*)	33.7 ± 3.5 (110)	34.7 ± 3.5 (138)	0.97
CREA (mmol/L), mean ± SD	73.94 ± 22.44	73.30 ± 20.13	0.89
LDL-C (mmol/L), mean ± SD	2.50 ± 1.06	2.41 ± 0.89	0.19
TG (mmol/L), median (range)	1.00 (1.00-2.00)	1.00 (1.00-2.00)	0.96
BNP (pg/mL), median (range)	91.5 (41.3-252.5)	70.0 (35.0-197.0)	0.22
hs-TnI (ng/mL), median (range)	0 (0-1.00)	0 (0-1.00)	0.99

GC: guiding catheter; JL: Judkins left; MI: myocardial infarction; PCI: percutaneous coronary intervention; UA: unstable angina; AMI: acute myocardial infarction; LVEF: left ventricular ejection fraction; LV-D: left ventricular diameter; AAD: ascending aorta diameter; CREA: creatinine; LDL-C: low-density lipoprotein-cholesterol; TG: triglyceride; BNP: B-type natriuretic peptide; hs-TnI: hypersensitive troponin I. *cases with available data.

Table II. Lesion-related and procedural characteristics.

Characteristics	Routine GC (n = 136)	JL 3.5 (n = 175)	*p*
Radial access, n (%)	136 (100)	175 (100)	
GC size 7Fr, n (%)	4 (2.9)	0	0.04
Classification of coronary lesions, n (%)			0.53
A	23 (16.9)	38 (21.7)	
B	46 (33.8)	59 (33.7)	
C	67 (49.3)	78 (44.6)	
Takeoff of right coronary artery, n (%)			0.14
Horizontal	74 (54.4)	89 (20.0)	
Inferior	35 (25.7)	35 (20.0)	
Superior	27 (19.9)	51 (29.1)	
Calcification, n (%)			0.24
Non or mild	101 (74.3)	137 (78.3)	
Moderate or severe	35 (25.7)	38 (21.7)	
Tortuosity, n (%)			< 0.001
Straight or mild	117 (86)	110 (62.9)	
Moderate or severe	19 (14.0)	65 (37.1)	
Ostial lesion, n (%)	20 (14.7)	12 (6.9)	0.02
CTO, n (%)	12 (8.8)	14 (8)	0.48
ISR, n (%)	4 (2.9)	15 (8.6)	0.03
Bifurcation technics, n (%)	6 (4.4)	9 (5.1)	0.49
Revascularization method, n (%)			0.78
DES	117 (86.0)	142 (81.1)	
DCB	14 (10.3)	22 (12.6)	
PTCA	6 (4.4)	11 (6.3)	
Procedure time (min)	24.7 ± 12.2	25.9 ± 15.7	0.48
Contrast volume (mL)	128.6 ± 29.8	130.3 ± 28.2	0.60
X-ray dose (mGy)	542.8 ± 382.4	567.3 ± 403.7	0.59
In-hospital complication, n (%)	3 (2.2)	8 (4.6)	0.21
Extra support technic, n (%)	4 (2.9)	9 (5.1)	0.25
Success, n (%)	132 (97.1)	164 (93.7)	0.14

GC: guiding catheter; JL: Judkins left; CTO: chronic total occlusion; ISR: in-stent restenosis; DES: drug-eluting stent; DCB: drug-coated balloon; PTCA: percutaneous transluminal coronary angioplasty; PBA: plain balloon angioplasty.

Multivariable Logistic Analyses in All Patients

A multivariable logistic regression model was established in all patients, including GC, left ventricular ejection fraction (LVEF), ISR, CTO, calcification, and tortuosity. The GC was not associated with intervention success, extra support technics, or in-hospital complications. CTO was negatively associated with intervention success (OR = 0.06, 95% CI: 0.016-0.248, $p < 0.001$). CTO and moderate/severe tortuosity were positively associated with the need for extra support technics (CTO: OR = 8.74, 95% CI: 1.518-50.293, $p = 0.015$; tortuosity: OR = 16.50, 95% CI: 3.324-81.589, $p = 0.001$) (Table IV).

Multivariable Logistic Analyses in the JL 3.5 Group

A multivariable logistic regression model was established in the JL 3.5 group, including LVEF, ISR, CTO, calcification, and tortuosity. LVEF was positively correlated with RCA procedural success (OR = 1.11, 95% CI: 1.03-1.20, $p = 0.006$), while CTO and moderate/severe tortuosity negatively associated with procedural success (CTO: OR = 0.07, 95% CI: 0.008-0.515, $p = 0.009$; tortuosity: OR = 0.17, 95% CI: 0.03-0.95, $p = 0.043$) (Table IV). ISR and moderate/severe tortuosity were positively correlated with the need for extra support technics during RCA intervention (ISR: OR = 6.75, 95% CI: 1.02-44.7, $p = 0.048$; tortuosity: OR = 7.36, 95% CI: 1.29-42.16, $p = 0.025$). LVEF was negatively associated with in-hospital complications (OR = 0.92, 95% CI: 0.86-0.99, $p = 0.033$) (Table V).

Discussion

The use of JL 3.5 appears to achieve a success rate similar to routine GC for RCA PCI *via* the transradial access. JL 3.5 GC is not associated with increased rates of in-hospital complications and extra support technics. LVEF, CTO, and

Table III. Cases with complications and failure.

Case	GC	Gender	Age (years)	Diagnosis	LVEF (%)	Classification of coronary lesions	Takeoffs	Calcification	Tortuosity	Ostial lesion	CTO	ISR	In-hospital complications	Failure
1	AL 0.75	F	68	UA	60	C	Inferior	Moderate	None	No	Yes	No	No	Residual stenosis greater than 30%
2	JL 3.5	M	63	AMI	54	C	Superior	None	Severe	No	No	No	No	Severe thrombus burden and TIMI 2 after dilation
3	JL 3.5	M	45	AMI	56	C	Horizontal	None	Mild	No	Yes	No	No	Failure of guidewire pass through
4	JL 3.5	M	71	UA	0	C	Horizontal	Severe	None	Yes	Yes	No	No	Failure of guidewire pass through
5	JL 3.5	M	63	AMI	51	B	Superior	None	Moderate	No	No	No	No	Guidewire into the subintimal space
6	AL 0.75	M	61	UA	64	C	Horizontal	None	None	Yes	Yes	No	No	Failure of guidewire pass through
7	JL 3.5	F	81	UA	66	C	Superior	None	None	No	Yes	No	No	Failure of guidewire pass through
8	JL 3.5	M	62	AMI	62	C	Inferior	Moderate	Severe	No	No	No	Side branch occlusion	Success
9	JL 3.5	F	60	AMI	57	B	Superior	Mild	Mild	No	No	No	Proximal dissection caused by GC	Success
10	AL 1.0	M	55	UA	57	C	Horizontal	Severe	None	Yes	Yes	Yes	Ostial and aortic sinus dissection caused by GC	Ostial and aortic sinus dissection caused by GC
11	JL 3.5	M	64	AMI	26	B	Superior	Severe	None	No	No	Yes	Intraoperative acute coronary occlusion	Death
12	JR 4.0	F	65	AMI	68	B	Horizontal	Moderate	None	No	No	No	Severe thrombus burden and no-reflow	Death
13	JR 4.0	M	56	UA	74	B	Inferior	None	Moderate	No	No	No	Lesion dissection	Success
14	JL 3.5	M	53	UA	36	C	Horizontal	Mild	None	No	Yes	No	Adventitial dissection	Guidewire into the subintimal space
15	JL 3.5	F	62	UA	73	A	Superior	None	None	No	No	No	Dissection of proximal stent edge	Success
16	JL 3.5	F	69	AMI	61	C	Superior	None	Severe	No	No	No	Hematoma of distal stent edge	Residual stenosis greater than 90% and TIMI 2
17	JL 3.5	F	68	UA	44	C	Horizontal	Mild	Severe	No	No	No	Hematoma of proximal stent edge	Residual stenosis greater than 90%
18	JL 3.5	M	73	AMI	53	B	Inferior	Severe	Moderate	No	No	No	Dissection of distal and middle RCA	Dissection of distal and middle RCA and TIMI 2
19	JL 3.5	M	71	AMI	50	C	Inferior	Severe	Severe	No	No	No	No	Extremity access arterial and coronary tortuosity

GC: guiding catheter; AMI: acute myocardial infarction; UA: unstable angina; JL: Judkins left; AL: Amplatz (left); JR: Judkins right; LVEF: left ventricular ejection fraction; CTO: chronic total occlusion; ISR: in-stent restenosis; RCA: right coronary artery; TIMI: thrombolysis in myocardial infarction.

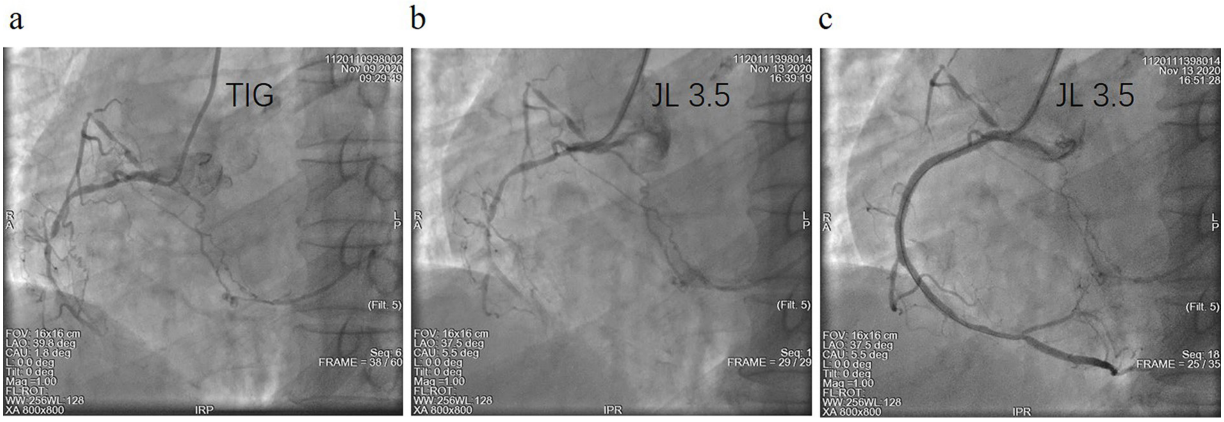

Figure 1. Cannulation of the RCA using JL 3.5 (a case with diffused and subtotal occlusion lesion). **a**, Angiography with TIG showing diffused and subtotal occlusion lesion. **b**, JL 3.5 guiding catheter with great coaxiality. **c**, Successful intervention with JL 3.5.

moderate/severe tortuosity are associated with procedural success in RCA intervention by JL 3.5.

Undoubtedly, the catheter backup force plays an important role in PCI success[21]. With good manipulation and minimal complications, the JR GC is often used in RCA PCI. Ikari et al[21] constructed an aorta model to evaluate the mechanics of the backup force. They showed that the primary attachment site of JR 4.0 was the brachiocephalic arteries in the right transradial approach. Due to anatomical reasons, the brachiocephalic artery cannot provide enough passive support, leading to a weak backup force of the JR GC in the transradial approach, and it can easily disengage from the right coronary artery ostium[3,6-8].

The Amplatz (left) GC is a strong support catheter for RCA PCI. In the aorta model by Ikari et al[21], just like the JR, the primary attachment site of the Amplatz (left) is the brachiocephalic artery in the transradial approach. Still, the second bend of the Amplatz (left) GC can attach to the contralateral wall of the ascending aorta or Valsalva sinus. Hence, the Amplatz (left) GC can provide strong backup support[3,6-8]. Suresh and Neelam[9] showed that the JL 3.5/4 could be used as a multipurpose guiding catheter for simultaneous right and left PCI in most situations. It results in shorter procedure time, smaller contrast volume, and fewer complications. The Ikari left (IL) 3.5 GC has a shape similar to the JL 3.5 except for the area of the brachial-cephalic angle. Youssef et al[22] reported that using the IL 3.5 as a single GC is feasible for most transradial right and left coronary PCI cases. From their models, Ikari et al[21] generated the formula $F_{max} = k(\cos\theta' + \lambda)/\cos\theta$, where k is a constant determined by the GC size,

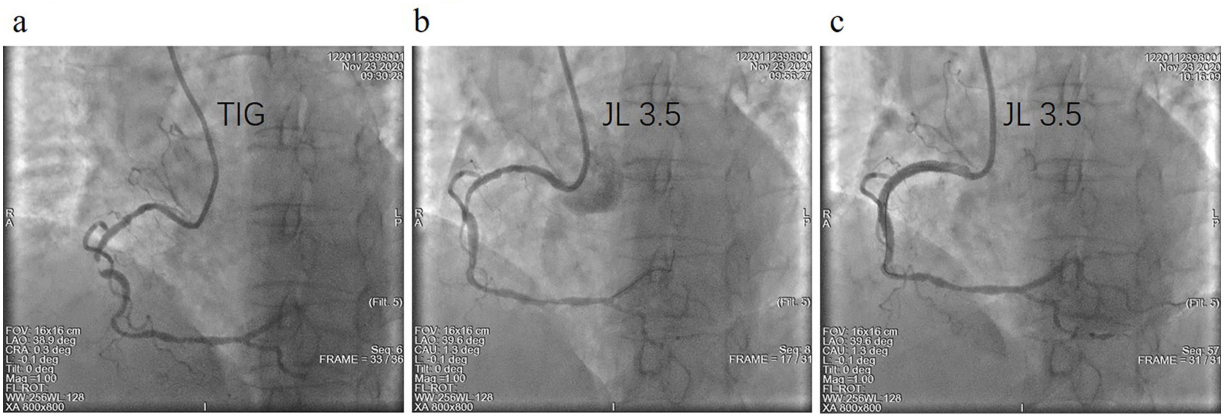

Figure 2. Cannulation of the RCA using JL 3.5 (a case with diffuse and moderately tortuous lesion). **a**, Angiography with TIG showing diffuse and moderately tortuous lesion. **b**, JL 3.5 guiding catheter with great coaxiality and backup force. **c**, Successful intervention with JL3 .5.

Table IV. Multivariable logistic analyses in all patients (n = 306).

	Success		Extra support technic		In-hospital complication	
Characteristics	**OR (95% CI)**	***p***	**OR (95% CI)**	***p***	**OR (95% CI)**	***p***
LVEF	1.05 (0.99-1.12)	0.12	1.01 (0.93-1.10)	0.83	0.98 (0.92-1.05)	0.65
ISR	0.50 (0.09-2.86)	0.43	3.42 (0.53-21.97)	0.20	2.68 (0.48-15.00)	0.26
CTO	0.06 (0.02-0.25)	< 0.001	8.74 (1.52-50.29)	0.02	2.85 (0.52-15.76)	0.23
Calcification	0.56 (0.16-1.92)	0.35	3.26 (0.89-11.91)	0.07	2.52 (0.70-9.08)	0.16
Tortuosity	0.30 (0.08-1.11)	0.07	16.50 (3.32-81.86)	0.001	2.43 (0.66-8.98)	0.19
JL3.5	0.48 (0.13-1.82)	0.28	1.09 (0.27-4.47)	0.91	1.79 (0.43-7.45)	0.42

OR: odds ratio; CI: confidence interval; LVEF: left ventricular ejection fraction; ISR: in-stent restenosis; CTO: chronic total occlusion; JL 3.5: Judkins left 3.5.

Table V. Multivariable Logistic analyses in the JL 3.5 group (n = 171).

	Success		Extra support technic		In-hospital complication	
Characteristics	**OR (95% CI)**	***p***	**OR (95% CI)**	***p***	**OR (95% CI)**	***p***
LVEF	1.11 (1.03-1.20)	0.01	0.96 (0.88-1.06)	0.23	0.92 (0.86-0.99)	0.03
ISR	0.80 (0.07-9.27)	0.89	6.76 (1.02-44.70)	0.048	1.02 (0.09-11.32)	0.70
CTO	0.07 (0.01-0.52)	0.01	5.71 (0.45-72.24)	0.53	1.80 (0.37-8.72)	0.53
Calcification	0.99 (0.19-5.18)	0.47	0.72 (0.11-4.76)	0.78	1.80 (0.37-8.72)	0.24
Tortuosity	0.17 (0.03-0.46)	0.04	7.36 (1.85-42.16)	0.03	1.87 (0.40-8.71)	0.45

OR: odds ratio; CI: confidence interval; LVEF: left ventricular ejection fraction; ISR: in-stent restenosis; CTO: chronic total occlusion.

θ' is the upside angle between the GC and aorta, θ is the downside angle between the GC and aorta, and λ is the frictional force. This formula can mathematically show that the backup force of the JL 3.5 is higher than for the other GCs during RCA PCI *via* the transradial access[9].

In this study, the JL 3.5 appeared to provide adequate backup in some cases with diffuse lesions (a typical case is shown in Figure 1), calcification, or tortuosity (a typical case is shown in Figure 2). The JL 3.5 appeared to achieve the same success as the routine RCA GCs and did not increase the in-hospital complications or the need for extra support technics. Only one patient in each group showed a dissection caused by the GC, while the other dissections occurred after balloon dilation or stenting. Failure of the guidewire to pass through the lesion was the most common reason for procedural failure. This study suggests the potential benefits of JL 3.5 for transradial RCA PCI. Moderate and severe tortuosity makes it difficult to pass the balloon or stent through the lesions, increasing the difficulty of PCI and the risks and complications. In agreement with previous studies[5,9,23], even if JL 3.5 has a good backup force, a lesion with tortuosity is an important factor leading to intervention failure and in-hospital complications. The risk of PCI in patients with heart failure will be greatly increased, and heart function should be closely monitored. Like calcification, stents will stiffen the blood vessels and make it difficult for instruments to pass through. This study found that ISR and moderate/severe tortuosity were positively correlated with extra support technics.

The JL 3.5 catheter provides a new treatment catheter for RCA interventional therapy, which can obtain the same support force as a conventional catheter without increasing complications and the proportion of auxiliary support technology. JL 3.5 is a left coronary intervention catheter. Combined with its advantages in RCA intervention, JL 3.5 can be used as a multifunctional catheter for left and right coronary intervention. Hence, it could have the potential for a single GC to manage multivessel disease, but that question will have to be examined later. Nevertheless, according to the takeoff data of the RCA in Table II, there were no differences between the JL 3.5 and conventional catheters. The success rate, complications, and proportion of auxiliary support technology used in the two groups are similar. Therefore, the JL 3.5 catheter could be adapted to various RCA anatomical types.

Limitations

The study had some limitations. It was a retrospective study, with all the inherent biases and limitations. The data were limited to those available in the patient charts. It was a single-center study, and the sample size was relatively small. In addition, because of the small number of patients, the control group included more than one type of GC, possibly influencing the results. Additional multicenter clinical evidence is required to support the conclusions. Patients with left coronary artery PCI using the JL 3.5 were not included, preventing the conclusion that the JL 3.5 can be used as a multifunctional GC.

Conclusions

Using JL 3.5 contributes to an equal success rate to routine GC for RCA PCI *via* transradial access. JL 3.5 GC is not associated with increased rates of in-hospital complications and extra support technics. LVEF, CTO, and moderate/severe tortuosity are associated with procedural success in RCA intervention by JL 3.5. The JL 3.5 catheter can possibly be adapted to various RCA anatomical types, but it will have to be confirmed in a large sample size allowing subgroup analyses based on RCA anatomy.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Authors' Contributions

Zhi Yan, Xiaowei Xing, Xuguang Zhang, Xin Wang, Jiangying Kuang, Qinghua Lu contributed to the conception or design of the work or the acquisition, analysis, or interpretation of data for the work. Xuguang Zhang and Xin Wang helped to draft the manuscript. All authors read and approved the final manuscript. We confirm that all listed authors meet the criteria for authorship as per the ICMJE criteria.

Availability of Data and Materials

All data generated or analyzed during this study are included in this article..

Ethics Approval

This research was approved by the Ethics Committee of the Second Hospital of Shandong University (No. KYL-2021(LW)006).

Informed Consent

The requirement for individual consent was waived by the Committee because of the retrospective nature of the study.

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