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Original Article

Judkins left catheter size selection during right trans-radial coronary angiography using preprocedural coronary computed tomography angiography

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Abstract

Objectives: Proper catheter selection during right trans-radial coronary angiography reduces procedure duration, costs, and vascular complications. The correlation between aorta morphological parameters assessed through computed tomography (CT) and requirement for larger catheter size was investigated in this study. **Materials and Methods:** This observational study includes 206 patients who underwent right trans-radial coronary angiography and had already undergone coronary CT angiography at a recognized center from April 2023 to January 2025. Patients who completed angiography using a Judkins left (JL) 3.5 (Group 1) catheter were compared with patients who required catheter exchange with a JL 4 or larger (Group 2). Both groups had their CT images analyzed for four specific aortic morphological variables. **Results:** A total of 167 patients formed Group 1, whereas 39 patients formed Group 2. The significant differences were detected in the maximal area and length of the ascending aorta among the four aortic CT variables. In multivariable logistic regression model, the strongest association with the need for JL4 or more catheter (Group 2) was found with the maximal area of the ascending aorta (odds ratio [OR] 31.82 [(95% confidence interval [CI]) 1.21–831.18], $P < 0.001$) followed by length of the ascending aorta (OR 29.97 [(95% CI) 1.06–845.08], $P < 0.001$). An ascending aorta maximal area cutoff value was 12.25 cm^2 (SN 94.9%, SP 95.2%) with the derived diameter of 3.94 cm. **Conclusion:** Maximum area (with derived diameter) and ascending aortic length were the good predictors for suitable catheter selection during right trans-radial invasive coronary angiography.

Keywords: *Aortic morphology, Coronary angiography, Coronary diagnostic catheters, Left coronary artery, Trans-radial coronary angiography*

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Introduction

Invasive coronary angiography is the definitive method for visualizing coronary arteries and evaluating the presence and degree of stenotic lesions [1]. The judicious choice of the initial catheter may diminish contrast utilization, excessive catheter manipulation, procedural duration, costs, and the risk of vascular injuries.

Coronary angiography often uses Judkins left (JL) catheter, which has a primary curve and a secondary curve. The catheter's easy engagement into the left coronary ostium is facilitated by the primary (distal) curve, while the secondary (proximal) curve is intended to ensure catheter stable position by touching the contralateral aortic wall. Stability can be achieved in cases of aortic dilation only by using a catheter with a larger curvature [2]. In the absence of a well-defined catheter selection strategy for a dilated aorta, the choice largely relies on the practitioner's previous experiences in nearly all situations. Thus, computed tomography (CT) indices indicative of aortic dilation were assessed in this study to determine suitable catheter selection.

Coronary CT angiography and coronary artery calcium (CAC) score were practically helpful in assessing coronary arteries [3,4]. Because of its noninvasive nature and low risk of significant complications, it is frequently conducted before invasive coronary angiography. Nevertheless, its widespread

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adoption has diminished the chances for new interventionists to become proficient to perform invasive coronary angiography [5,6]. Even for operators with less experience, optimizing the process could be achieved by obtaining valuable information, such as aortic morphology, which requires a different diagnostic catheter prior to angiography, in the current era of limited invasive coronary angiography opportunities.

At this time, there is a lack of consensus among medical professionals regarding the optimal size of the JL catheter based on the ascending aorta and other relevant characteristics. Consequently, this study assesses the CT aortic morphological characteristics in patients who needed a diagnostic catheter with a bigger curve (JL4 or more) to engage the left coronary artery.

Materials and methods

Study population

Data were gathered from patients who completed right trans-radial diagnostic invasive coronary angiography, who had already undergone coronary CT angiography at Ibn al-Bitar Specialized Center for Cardiac Surgery from April 2023 to January 2025. The institution was a high-volume transradial center. Two operators undertook transradial coronary angiography. The cardiologists who performed the procedure had the experience of over 4 years. The patients included in the study were those who underwent angiography with a JL 3.5 catheter (Group 1, control) from the first attempt or were able to complete angiography with JL 4 or higher catheter (Group 2) after failure of JL 3.5 catheter. The diameter of all diagnostic catheters utilized was 6 Fr.

Exclusion criteria included patients who underwent simultaneously coronary artery bypass angiography, those who developed significant radial spasm or changed to femoral access, those who undergone cardiac surgery between the coronary CT angiography and invasive coronary angiography, those with more than 6 months between the two tests due to the possible aortic alterations that could occur, who undergone the procedure with just one catheter, individuals whose CT scans had low-quality images that could not be evaluated using automated measuring software, and those who suffered from significant aortic stenosis or regurgitation.

Height, weight, and cardiovascular risk factors (hyperlipidemia, hypertension, and diabetes) were analyzed as the factors that are relevant to catheter selection. The duration of the procedure and the amount of contrast material utilized for invasive coronary angiography were documented.

Computed tomography acquisition and interpretation

Images of the aorta were obtained by a single-source multidetector CT examination (Brilliance 64, Philips Medical Systems, the Netherlands) [4]. Cardiac acquisition protocol with electrocardiogram (ECG) gating and body mass index weighted tube voltage (100–140 kV) was used. At a 6 mL/s flow rate, 70–90 mL of intravenous iodixanol contrast was administered, and then 30 mL of saline flush was injected at the same settings. In addition, the contrast volume was calculated using the patient's weight. A slice thickness of 0.75 mm and 512 × 512 image matrix were used for image reconstruction.

An analysis was conducted on aortic morphological characteristics utilizing Comprehensive Cardiac Analyses, Brilliance Workstation (Philips Healthcare, the Netherlands). The CT scans were used to evaluate four morphological factors related to the aorta and coronary arteries: first, the aortic angle, which is the angle formed by the horizontal line and the aortic centerline; second, the angle formed by the left coronary ostium [7]; third, the ascending aorta maximal area, automatically determined using a curved multiplanar reconstruction (MPR) image that identifies the aorta centerline; fourth, the ascending aorta length is measured on the same curved MPR view and is defined as the distance from the Valsalva sinus to the origin of the brachiocephalic artery as shown in Figure 1. A cardiologist with competence in cardiac CT reviewed all the images.

The Local Ethics Committee in the researcher institution approved this study (REG0304/2023) on April 3, 2023, which was carried out in compliance with ethical standards outlined in the 1975 Declaration of Helsinki. Informed consent was obtained from patients.

Statistics

Continuous normally distributed variables are expressed as mean ± standard deviation and compared between research groups by independent samples *t*-test. For nonnormally distributed variables, continuous variables are presented as medians with first and third interquartile ranges and were

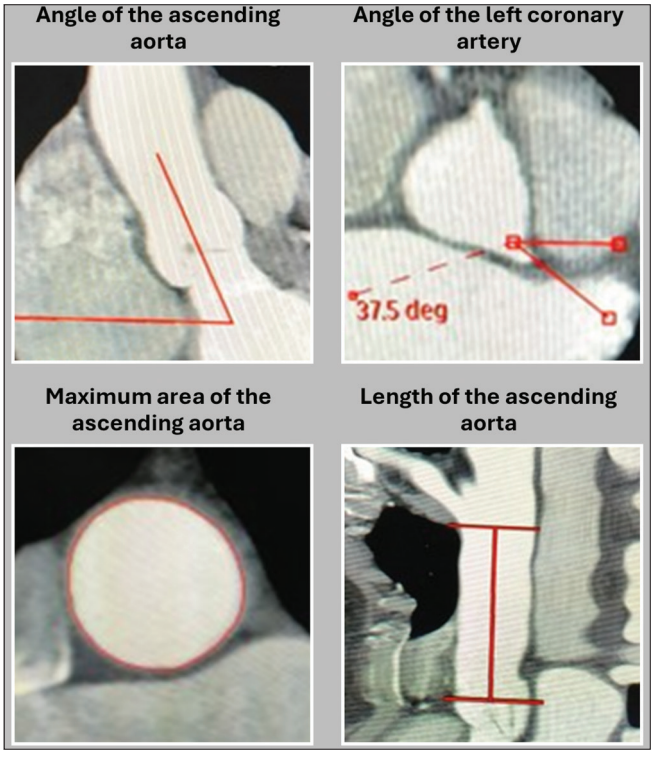

Figure 1: An example of the computed tomography images showing the methods used to measure the four morphological aortic parameters

compared using the nonparametric Mann–Whitney *U*-test. Frequencies and percentages are used to represent the categorical variables and are analyzed by Pearson's Chi-square test. The logistic regression analysis was used to identify multivariate parameters for the requirement for a JL4 or more catheter. The results are shown as odds ratios (ORs) with 95% confidence intervals (CIs). Sensitivity and specificity were calculated using a receiver operating characteristic (ROC) curve, followed by the selection of the cutoff value. Statistical significance was defined as a $P < 0.05$. IBM SPSS software version 27 (SPSS, Inc., Chicago, IL, USA) was used to conduct all statistical analyses.

Results

Baseline characteristics

A total of 167 patients in Group 1 (JL3.5) and 39 patients in Group 2 (JL4 or more) were investigated in this research. The mean age of both groups was 62.5 ± 8.5 years, with 134 patients (65%) being male. No statistical difference was observed in height, weight, and hyperlipidemia between the groups. Group 2 was found to have a higher proportion of hypertension (84.6% vs. 64.7%, $P = 0.01$), diabetes (56.4% vs. 38.9%, $P = 0.01$), smoking (71.8% vs. 48.5%, $P = 0.009$), higher procedure time (29.92 vs. 18.71 min, $P < 0.001$), and contrast volume (64 mL vs. 47.34 mL, $P < 0.001$) [Table 1].

Table 1: Patient's baseline characteristics

	Group 1 (n=167)	Group 2 (n=39)	*P*
Age (year)	62.11±8.7	64.17±7.4	0.176
Male, *n* (%)	108 (64.7)	26 (66.7)	0.81
Body height (cm)	167.81±7.2	170.22±6.7	0.062
Body weight (kg)	83.20±12.0	85.61±11.8	0.26
Hypertension, *n* (%)	108 (64.7)	33 (84.6)	0.01
Diabetes mellitus, *n* (%)	65 (38.9)	22 (56.4)	0.01
Hyperlipidemia, *n* (%)	68 (40.7)	21 (53.8)	0.13
Smoking, *n* (%)	81 (48.5)	28 (71.8)	0.009
Procedure time (min)	18.71 (14.36–21.84)	29.92 (27.04–35.87)	<0.001
Contrast volume (mL)	47.34 (42.21–52.68)	64 (58.78–72.03)	<0.001

Table 2: Differences in aortic computed tomography findings between group 1 and group 2

	Total (n=206)		*P*
	Group 1 (*n*=167)	Group 2 (*n*=39)	
Angle of the ascending aorta (°)	46.68 (39.20–56.41)	47.74 (43.25–53.20)	0.477
Angle of the left coronary artery (°)	34.68 (27.59–42.09)	30.36 (24.01–42.28)	0.113
Maximum area of the ascending aorta (cm^2)	10.15 (9.22–11.14)	15.31 (13.92–17.83)	<0.001
Length of the ascending aorta (cm)	8.02 (7.51–8.50)	9.97 (8.97–10.82)	<0.001

Computed tomography findings

In Group 2 (JL4 or more), the ascending aorta had a greater maximal area compared to Group 1 (JL3.5) (Group 2, 15.31 cm^2 (13.92, 17.83); Group 1, 10.15 cm^2 (9.22, 11.14); $P < 0.001$). Furthermore, the ascending aorta length (Group 2, 9.97 cm (8.97, 10.82); Group 1, 8.02 cm (7.51, 8.50); $P < 0.001$) was greater in Group 2 than in Group 1 [Table 2].

When all of these predictors were taken into account in the multivariable logistic regression model, the maximum area of the ascending aorta (OR 31.82, 95% CI 1.21–831.18, $P = 0.038$) and length of the ascending aorta (OR 29.97, 95% CI 1.06–845.08, $P = 0.046$) show a statistically significant association with catheter change [Table 3].

Since the maximal ascending aortic area is relevant in both multivariate analysis and clinical practice, it was given special attention. For patients who need a coronary catheter with a larger curvature, the optimal cutoff value and area under the curve (AUC) for the ROC curve of the maximal ascending aorta area were 12.25 cm^2 (SN 94.9%, SP 95.2%) and 0.994 (95% CI 0.98–1.00), respectively [Figure 2]. Aortic diameter 3.94 cm was the matching value obtained from the above cutoff. The cutoff value and AUC for the ROC curve of the ascending aorta length were 8.66 cm (SN 87.2%, SP 82%) and 0.942 (95% CI 0.90–0.98), respectively.

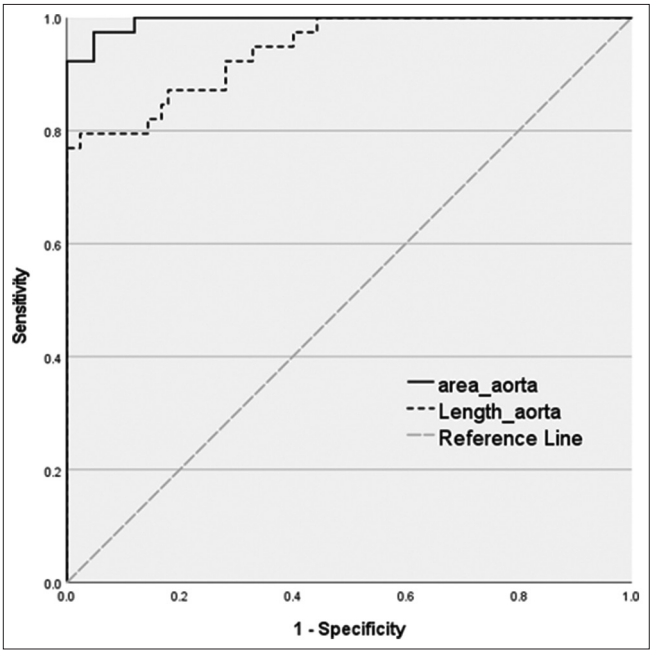

Figure 2: Receiver operating characteristic curve of the maximum area of the ascending aorta and ascending aortic length for using Judkins left 4 or more catheter (Group 2)

Discussion

The study found that out of the four aortic morphological findings on CT, the maximal ascending aortic area was the most important parameter in determining whether a JL4 or larger catheter was used for right trans-radial approach coronary angiography. A maximal ascending aortic area of 12.25 cm^2 was considered cutoff, with a calculated diameter of 3.94 cm. Compared to the JL3.5 group, the JL4 or larger group needed more contrast and longer procedural time for invasive coronary angiography.

The trans-radial approach has gained popularity in recent years due to its advantages over the femoral approach, even in noncardiac interventions like neuro-and thyroid

Table 3: Aortic data of patients requiring Judkins left 4 or more catheter (group 2) was analyzed by univariate and multivariate methods

	Univariate analysis			Multivariate logistic analysis		
	OR	95% CI	*P*	OR	95% CI	*P*
Angle of the ascending aorta (°)	1.01	0.97–1.05	0.620	1.13	0.842–1.521	0.412
Angle of the left coronary artery (°)	0.97	0.93–1.01	0.144	0.81	0.587–1.127	0.215
Maximum area of the ascending aorta (cm^2)	47.57	4.65–485.87	<0.001	31.82	1.21–831.18	0.038
Length of the ascending aorta (cm)	75.63	12.00–476.68	<0.001	29.97	1.06–845.08	0.046

CI: Confidence interval, OR: Odds ratio

interventions [8-10]. This approach results in a shorter hospital stay, the ability to walk following the procedure, and even same-day discharge. In addition, it reduces patient discomfort, bleeding, and mortality (in STEMI) [9,11,12]. These procedures have a learning curve, and beginner practitioners may not receive adequate training [13]. There are numerous advantages to establishing guidelines for the selection of an appropriate catheter during trans-radial coronary angiography, including reduced procedure time, prevention of vascular complications, and reduced costs [14]. The risk of iatrogenic aortic dissection is particularly important, as it is frequently reported in cases involving a trans-radial approach and may be the result of frequent and improper catheter manipulation, which can have catastrophic consequences [15].

The JL catheter is developed to facilitate engagement of the left coronary artery and is simple to manipulate, thereby enabling fast and reliable selective coronary engagement, and JL4 size was developed at the beginning for femoral access [16]. There are major variations in the catheter pathways for the left coronary artery between femoral, left trans-radial, and right trans-radial approaches [17]. JL catheters were made in a variety of sizes, ranging from 3 cm to 6 cm, based on the length of the primary and secondary curves. A catheter with a larger curve is preferred as the aortic diameter increases [2]. In the absence of a dilated aortic root, a JL 4.0 catheter is recommended for coronary angiography through the femoral artery. Nevertheless, a JL 3.5 catheter is more optimal for right trans-radial coronary angiography due to anatomical considerations and is considered the default and initial catheter in the current study. Although it is recognized that ascending aorta dilation, aortic rotation, ascending aorta angle, and aortic elongation are all significant factors [18], the exact ascending aortic dimensions and the predictors for using JL4 catheter in right trans-radial approach have not been thoroughly examined.

The advantage of the transradial artery access with a single coronary catheter has been demonstrated in several previous studies and trials and includes diminished radial artery spasm, lesser contrast amount, and fluoroscopy time [19-21]. Nevertheless, other studies found that the two-catheter approach was superior to the one-catheter technique regarding procedural duration for the male and young subjects [22-24]. There is still no clear answer to the question of whether a one-or two-catheter method is better. The Judkins catheter is ubiquitous and more available in the cath labs than the more specialized single catheters because it is used in the older and more widespread femoral approach.

The noninvasive nature of CT coronary angiography and its capacity to provide valuable data, such as the CAC score and plaque burden, are the rationale for it to be performed more frequently prior to invasive coronary angiography [4] and it is emphasized in many guidelines for the assessment of chest pain [3]. As chances for new interventionists to acquire expertise in conducting diagnostic invasive coronary angiography have declined in recent years, it is imperative to obtain information beforehand in order to optimize the procedure. Mediastinal-cardiac ratio by simple chest radiography and aortic root diameter by echocardiography were found to be good predictors for appropriate catheter selection during left trans-radial approach [25], while the current study includes right trans-radial approach only. According to another study using CT, invasive coronary angiography may be better performed in individuals with an ascending aorta diameter larger than 38 mm if JL5 is chosen as the first diagnostic catheter [26], but in most patients, they used left trans-radial and femoral approaches, which require larger JL sizes than right trans-radial approach [27]. To my knowledge, this is the first study that investigates the prediction of JL catheter size by CT parameters in patients undergoing right trans-radial approach only.

In this study, the cutoff values were 12.25 cm^2 for the ascending aorta maximal area, and 8.66 cm for the ascending aorta length might be useful in determining whether a JL4 or larger catheter could be used for right trans-radial approach coronary angiography. By the multivariable logistic regression model, the maximum area of the ascending aorta (OR 47.57) and length of the ascending aorta (OR 47.57) were the good predictors for selecting the catheter. The diameter cutoff value of 3.94 cm is appropriate, considering that the JL4 catheter has a 4 cm curve. These results suggest that performing first-attempt right trans-radial approaches with the JL4 in all cases when the ascending aortas are more than 3.94 cm dilated on pre-procedural CT may lessen contrast volume, procedural time, and costs, and potentially reduce complications such as spasm [28] and aortic dissection [15] and contrast-induced nephropathy.

The aorta undergoes dilation and elongation as it ages as a result of structural stress from cyclic tensions [29]. In addition, as people get older, there are noticeable changes in the dimensions of the aortic arch and the diameter of the ascending aorta [30]. However, the age gap between the two sets of data was not statistically significant. One possible explanation is that Group 2 (JL 4 or more) patients might have more atherosclerosis with higher percentage of smokers, diabetic, and hypertensive patients.

The procedure can be potentially optimized without the need for additional tests, costs, or risk to the patient

by selecting the first-attempt diagnostic catheters for invasive coronary angiography based on aortic morphology from pre-procedural CT images. Given that this study exclusively included patients who underwent CT scans prior to invasive coronary angiography, it is recommended that additional studies be conducted to investigate the selection of appropriate guiding catheters in percutaneous coronary interventions and to incorporate other modalities like chest X-ray, magnetic resonance imaging, ECG, and echocardiography. Additional investigation in prospective, randomized, and multicenter studies is required to evaluate the patient outcomes and clinical practice in future and also to investigate suitable diagnostic coronary catheters to use other than JL4 and JR4.

Study limitations

This research possesses certain limitations. This is a single-center and observational study with an unequal sample size between the control group (Group 1) and the switched group (Group 2), with the latter having a relatively small number of participants. The time and number of trials before catheter exchange were determined at the operator's discretion, potentially introducing operator bias into the results. In addition to the aforementioned predictive parameters, several factors, including technical issues arising from catheter exchange, may affect the outcomes. Finally, the use of these criteria is likely unnecessary for expert operators, and the findings of this study are deemed more applicable to novices in the transradial access.

Clinical repercussions

It is recommended to include the ascending aorta maximal area, diameter, and length in the coronary CT angiography report to assist in choosing the initial size of the JL catheter during invasive coronary angiography by right transradial approach.

Conclusions

During right transradial coronary angiography, ascending aortic maximal area correlates with diagnostic catheter size requirements (JL4 or larger). When patients have an ascending aortic diameter of 39 mm or larger, the JL4 can be used as the initial diagnostic catheter to optimize this approach by reducing contrast volume, minimizing the procedure time, and cutting costs.

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Data availability statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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