Original Article

Comparison of Moderate Blockage of Left Main Stem (LMS) Assessment on Catheter Angiography Versus Coronary Computed Tomographic Angiography

Comparison of Invasive and Non-Invasive Coronary Angiography

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ABSTRACT

Objective: To assess the diagnostic ability of non-invasive computed tomographic angiography (CTA) against invasive catheter angiography (ICA) in patients with moderate left main stem (LMS) (40-49%).

Study Design: Prospective Comparative Study

Place and Duration of Study: This study was conducted at the cardiology department of Ch. Pervaiz Elahi Institute of Cardiology Multan for one year from July 2020 to July 2021.

Materials and Methods: Computed tomography angiography (CTA) and invasive catheter angiography (ICA) were performed in 45 coronary lesions with moderate severity. Percent diameter stenosis (%DS) and Minimal lumen diameter (MLD) were assessed by ICA and CTA. Inducible ischemia was determined by fractional flow reserve (FFR) value less than 0.80. The diagnostic value of the two methods was compared.

Results: 8 (20%) lesions had FFR ≤0.80. Mean CTA MLD was found to be lower than mean ICA MLA (1.3 ± 0.5 vs. 1.5 ± 0.5 mm, $P < 0.001$). Similarly, mean CTA %DS was higher than ICA %DS (53.5% ± 14% vs. 49.8% ± 11.8%, $P < 0.001$). These findings remained independent of the location of the lesion, its severity, and its plaque nature. In terms of ischemia prediction, diagnostic value of CTA %DS was less than that of ICA %DS ($P = 0.04$).

Conclusion: Invasive and non-invasive methods vary by diagnostic criteria in terms of the detection of ischemia-producing coronary stenosis. Compared with ICA, CTA overestimates lesion severity and has a lesser diagnostic capacity to assess ischemia.

Key Words: Coronary stenosis, coronary lesions, computed tomography angiography, invasive catheter angiography, LMS

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INTRODUCTION

Invasive coronary angiography (ICA) is considered a gold standard for the accurate estimation of coronary artery disease. However, the more advanced coronary computed tomographic angiography (CCTA) technology has allowed anatomical assessment of the coronary arteries through a non-invasive protocol (1). Since CCTA has now been increasingly utilized for research and clinical purposes, it seems critical to assess the association between the parameters obtained from ICA and CCTA.

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Fractional flow reserve (FFR) is defined as an invasive psychological index to predict the existence of severe coronary stenosis that is capable to generate ischemia (2). Literature has frequently recommended the adoption of FFR-directed percutaneous coronary intervention protocol (3, 4). Computation of FFR is now perceived as the most reliable invasive strategy to evaluate the severity of coronary stenosis. The existing studies reported the inability of anatomical criteria to effectively predict ischemia-generating coronary stenosis (5, 6). However, to the best of our knowledge, no study has so far been conducted in Pakistan that compared the diagnostic accuracy of ICA to that CCTA in different lesion subsets. Thus, this study was designed to evaluate the diagnostic ability of non-invasive computed tomography angiography (CTA) against invasive catheter angiography (ICA) in patients with moderate left main stem.

MATERIALS AND METHODS

A prospective comparative study was conducted from 14th July 2020 to 14th July 2021 at the cardiology department of Ch.Pervaiz Elahi Institute of Cardiology Multan. Patients who had undergone ICA and FFR measurement from moderate left main stem (LMS) (visually 40-49%) in major coronary arteries and had CCTA within three months before ICA were included in the study. During the consecutive enrollment, patients diagnosed with the acute coronary syndrome; visible thrombosis in target vessel; lesion length greater than 40 mm; additional stenosis (greater than 30%) in the target vessel; left ventricular ejection fraction less than 40%; the existence of collateral vessel; myocardial heart disease, and idiopathic CCTA were excluded from the study. The participants were informed of the study's objective and consent was sought. The study was initiated after the approval of the ethical review board of the hospital.

CCTA was performed according to the guidelines published by the Society of Cardiovascular Computed Tomography (SCCT) [7]. Patients with heart rates greater than 65bpm were administered metoprolol orally and 0.2 mg nitroglycerin was given sublingually just before the scan. CCTA results were analyzed by two independent CT-reader who were kept blinded to the study's objective. Each of them analyzed each segment for minimal lumen diameter (MLD), plague characteristics, and % diameter stenosis (%DS). All the measurements were computed by analyzing minimal slice thickness [8]. Whereas long-axis views were used for % DS assessment as described in earlier studies [8]. Plagues were classified as calcified and non-calcified plaques.

For CA, 5- to 7- catheter was used to engage the targeted coronary artery. 100 to 200ug of nitroglycerin was administered followed by the acquisition of angiographic images. Measurement of FFR was carried out through .014-inch pressure sensor-tipped was as already explained [9]. Hyperemic state was achieved either through an intravenous infusion (145ug/kg/min) of adenosine or intracoronary bolus infusion (40ug in the right coronary artery and 80ug in the left coronary artery). Myocardial ischemia was diagnosed with an FFR value of ≤0.80 [9]. The quantitative analysis of CA was carried by an independent experienced observer who was unaware of CCTA findings and FFR value. Guide catheter was used for calibration and a reference for measurement of lesion length, MLD, and reference diameter. Lesion location was assessed by following the American Heart Association classification [10]. Lastly, % DS was calculated.

SPSS (version 18.0) was used for statistical analysis. Categorical variables were presented as percentages while continuous variables were presented as mean with corresponding standard deviations. Continuous variables of two techniques were compared through student's t-test. Similarly, paired t-test was used to compare the angiographic parameters of the two techniques. Whereas, the difference in categorical variables was assessed through *the* χ^2 test. The diagnostic value of CCTA and ICA in assessing myocardial ischemia (FFR ≤0.8) was evaluated by the “area under the curve” (AUC) calculated through the “receiver operating characteristic (ROC) curve" analysis. DeLong method was used to compare AUCs. The best correlation value (BCV) was computed through the highest sum of specificity and sensitivity. Association between FFR and ICA and CCTA parameters was determined through Pearson’s correlation coefficients. A P-value less than 0.05 for any variable was considered statistically significant.

RESULTS

A total of 30 patients with 45 lesions were consecutively included in the study. Table I and II present baseline characteristics of patients and their angiographic parameters. Mean FFR for all analyzed lesions was .83± .08 and 8 lesions (17.7%) had FFR ≤of 0.8. The majority of lesions with FFR ≤0.8 were found in the left anterior descending coronary artery compared to those with FFR greater than 0.8 that were majorly located in non-LAD lesions. Both ICA and CCTA exhibited smaller lumen and higher plaque deposition in the coronary lesions having FFR ≤ 0.80 than those with FFR> 0.80 (Table II).

The mean MLD measured by ICA was larger than that of CCTA (1.51±0.5 vs 1.28 ± 0.5, p<0.001). This trend remained the same regardless of plague characteristics, lesion severity, and lesion location (Table III). Positive correlation was found between ICA MLD and CCTA MLD (r = .448, P < .01) and ICA %DS and CCTA %DS (r = .443, P < 0.001). ICA MLD and CCTA MLD and ICA %DS and CCTA %DS had a 95% limit of agreement between the corresponding values with the following ranges: −1.2 to 0.8 mm and −23.3% to 32.6%, respectively. (Table III).

Table No.I: Baseline Data of the Participants (N=30)

Variables	Data
Age, years	59.8 ± 7.6
Male	19 (63.3%)
Risk factors	
Hypertension	22 (73.3%)
Diabetes mellitus	12 (40%)
Hyperlipidemia	16 (53.3%)
Clinical diagnosis	
Stable angina	10 (33.3%)
Silent ischemia	4 (13%)
Prior myocardial infarction	2 (7%)
Prior revascularization	7 (23.3)
Left ventricular ejection fraction, %	64.7 ± 7.5

A weak negative association was found between FFR CCTA %DS (r= -.25, p<.0001) whereas a weak positive association existed between FFR and ICA %DS (r= -.55, p<.01) Table IV. The functional significance of

FFR≤0.80 was assessed through calculation of BCVs that was 53.5% for CCTA %DS and 49.8% for ICA %DS. The diagnostic value of BCV for the prediction of ischemia existence was 59.9% for CCTA %DS and 67.2% for ICA% DS. Comparison of AUCs showed the significantly lower diagnostic value of CCTA %DS than ICA %DS (AUC area difference=.106, P=.002).

Table No.2: Angiographic and CCTA findings of the analyzed lesions

Parameters	All participants	FFR ≤0.8	FFR >0.8	P-value
N	30	8	22	
FFR	.83 ± 0.05	.76 ± .08	.88 ± 0.04	<.001
LAD lesion (*n*, %)	17	5 (62.5%)	12 (54.5%)	
Proximal lesion (*n*, %)	23	7 (87.5%)	16 (72.7%)	
Angiographic parameters				
Minimal lumen diameter (mm)	1.45 ± 0.3	1.3 ± .4	1.8 ± .5	<.01
Reference diameter (mm)	3.3 ± .5	2.9 ± .3	3.1 ± .3	.013
% diameter stenosis (%)	49.2 ± 11.8	57.6 ± 9.8	45.1 ± 11.1	<.01
Length of lesion (mm)	15.7 ± 8.7	16.6 ± 9.4	16.8 ± 8.9	0.88
CCTA parameters				
Minimal lumen diameter (mm)	1.29 ± .45	1.10 ± .5	1.3 ± .32	<0.01
Reference diameter (mm)	3.0 ± .4	2.7 ± .3	3.1 ± .2	0.03
% diameter stenosis (%)	53.5 ± 13.1	58.1 ± 12.5	51.2 ± 12.1	0.002
Lesion length (mm)	31.2 ± 11.2	28.9 ± 13.6	31.2 ± 11.1	0.54

LAD: Left anterior descending coronary artery

Table No.3: Comparison between ICA and CCTA parameters according to different lesion subsets

	CCTA MLD	ICA MLD	*P*-value
N=30	1.3 ± 0.5	1.5 ± 0.5	<.001
Lesion location			
LAD	1.28 ± .5	1.51 ± .5	<.0001
Non-LAD	1.41 ± 0.4	1.59 ± 0.6	0.0001
Reference vessel size by ICA (mm)			
≥3.0	1.32 ± .4	1.71 ± .6	.0001
<3.0	1.22 ± 0.3	1.45 ± .5	0.003
Calcified vs. Non-calcified plaque by CCTA			
Calcified	1.31 ± .5	1.50 ± .3	.002
Non-calcified	1.27 ± 0.4	1.51 ± 0.6	<0.001

LAD: Left anterior descending coronary artery

Table No.4: Association between FFR and ICA and CCTA parameters

Parameters	*N* (FFR ≤0.8)	Correlation (*r*)	
		CCTA %DS	ICA %DS
All participants	30 (22)	−0.25	−0.55
Lesion location			
LAD	17 (12)	−0.25	−0.54
Non-LAD	13 (10)	−0.31	−.57
Reference vessel size as per ICA (mm)			
≥3.0	18 (7)	−0.28	−.58
<3.0	12 (15)	−0.25	−0.56
Lesion length as per ICA (mm)			
≥20	7 (8)	−0.21	−0.55
<20	23 (14)	−0.29	−0.53
Calcified vs. non-calcified plaque as per CCTA			
Calcified	10 (7)	−0.265	−0.45
Non-calcified	20 (13)	−0.256	−0.59

DISCUSSION

This study reported: CCTA overestimated the stenosis severity as compared to ICA; CCTA findings had a weaker association with FFR than that of ICA parameters; this trend remained the same irrespective of the lesion characteristics, and CCTA has limited capacity in diagnosing ischemia-producing stenosis as compared to ICA. Although CCTA is capable enough to provide critical diagnostic information for the assessment of coronary artery disease, the existing literature has given contrasting judgments on the degree of agreement between ICA and CCTA parameters [11, 12]. We included the patients with intermediate stenosis (40-49%) who often pose challenges in deciding the need for revascularization. Majority of the lesion (76.6%) were clinically significant as there were found in the proximal site of prominent coronary arteries. In such significant lesions, CCTA parameters overestimated the severity of lesions when compared with ICA. Mean values of CCTA MLD and ICA MLD demonstrated a difference of 0.2 mm. It is important to understand this difference is clinically important particularly when a patient's assessment is made through two different imaging modalities. Previous related studies reported the inefficacy of CCTA in predicting the clinical significance of coronary stenosis [5, 13, 14]. However, these studies were limited in terms of patient selections-those with intermediate stenosis.

Our study also reported a weak correlation of CCTA parameters with FFR regardless of the lesion characteristic as compared to the other modality. Moreover, the diagnostic value of CCTA %DS in predicting the significance of stenosis was less than ICA %DS. This justifies the higher BCA of CCTA

%DS than ICA %DS (53.5% vs 49.8%). The functional inferiority could be due to the current temporal and spatial resolution of CCTA. This limitation, however, can be addressed by the utilization of novel techniques[15, 16]. CT-derived non-invasive FFR has been found to have the superior diagnostic capacity to CCTA %DS (84.3 vs. 58.5%) through computational fluid dynamics technology[16]. Since the technology allows three-dimensional analysis of coronary geometry, better estimation of lesion severity is predicted that too with the non-invasive technique [16]. However, based on these results it is anticipated that any new technology dependent on CCTA will be limited in diagnosis the severity of coronary stenosis.

However, this study is limited in several aspects. Firstly, the smaller study size with limited analyzed lesions might affect the accuracy of the study. Secondly, the exclusive inclusion of patients with intermediate stenosis might introduce selection bias. Lastly, the study hasn't provided the any findings related to clinical outcomes. Therefore, further studies are required to evaluate the clinical effects of the difference between invasive ICA and non-invasive CCTA.

CONCLUSION

Invasive and non-invasive methods vary by diagnostic criteria in terms of the detection of ischemia-producing coronary stenosis. Compared with ICA, CTA overestimates lesion severity and has a lesser diagnostic capacity to assess ischemia.

Author's Contribution:

Concept & Design of Study:	Muhammad Zubair
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Conflict of Interest: The study has no conflict of interest to declare by any author.

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