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Gender-associated dimensional differences among normal to non-flow limiting coronary artery dimensions

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ABSTRACT

Aim and objectives: To study gender-specific differences in coronary artery diameters among subjects with normal to non-flow limiting disease (NFLD) coronary arteries (up to 0 - 20% of stenosis) and to assess the possible association of body-mass index (BMI) with coronary dimensions, among the west coastal population of Karnataka and Kerala.

Materials and Methods: A prospective cohort study was conducted for a period of one year. Two thousand angiograms samples were collected and assessed from two study centers (one from each state), after obtaining the ethical clearance. Patients with past history of myocardial infarction and those with recanalized normal looking coronary arteries and those who had diabetes for more than five years were excluded. Ten segments of coronary arteries- left main coronary artery, ostial and proximal segments of left anterior descending artery and its first diagonal branch, ostial and proximal segments of left circumflex coronary artery and its obtuse marginal branch, ramus intermedius and the ostial and proximal segments of the right coronary artery- were included in diameter measurement. BMI values of the patients were calculated.

Results: Out of 2000 patients included in the study, 454 (22.7%; mean age 53.4 ± 14.2 years) had normal to NFLD coronaries of which 253 (55.7%) were males and 201 (44.3%) were females. As compared to women, men had larger diameters of coronary arteries for eight segments, except the obtuse marginal branch and the proximal right coronary artery. A weak, yet statistically significant, negative correlation existed between BMI and coronary artery diameters in total cohort, indicating that an increase in BMI was associated with a decrease in artery diameters. No such association was seen when men and women were assessed separately.

Conclusions: The present study indicates that men have higher caliber for coronary arteries compared to women. The study also indicates that when BMI increases there is a relative decrease in the coronary artery diameter.

1. Introduction

The caliber of coronary artery for main stems and their larger branches at ostium ranges between 1.5 and 5.5 mm. This is based on measurements of arterial casts or angiograms. The diameters of the coronary arteries may increase up to the 30th year of life.[1] The role of percutaneous coronary interventions (PCI) in patients with small vessels is not a well-defined treatment procedure. It has been hypothesized that women having a smaller coronary lumen[2] contributes to their increased risk of restenosis and repeated revascularization after coronary angioplasty. However, data regarding the same is limited, contradicting or not reliable. The present study intends to provide comprehensive data regarding whether gender differences exist in the coronary vessel lumen sizes.

Lower body mass index (BMI) cut-off values are recommended for Asians as compared to Caucasians. International Association for the Study of Obesity, the International Obesity Task Force and the World Health Organization proposed the BMI cut-points 23.0–24.9 kg/m^2 for being overweight and ≥25.0 kg/m^2 for obesity in adult Asians.[3] This revision was based on the fact that Asians had higher levels of

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Table 1
Gender-wise categorisation of study samples based on angiogram reports (n = 2000).

Sl. no.	Gender	Total samples (n = 2000)	Normal samples (n = 454)
1.	Male	1485 (74.3%)	253 (55.7%)
2.	Female	515 (25.7%)	201 (42.3%)

cardiovascular risk factors compared to Caucasians at any given BMI value.[4,5] The present study intends to find out whether there is a possible association between BMI and coronary artery dimensions.

2. Aim of the study

To study the coronary artery dimensions in patients with normal to non-flow limiting disease (NFLD) coronaries (up to 0–20% of stenosis in the branch vessels) and to assess the possible association of BMI with coronary dimensions, among a west coastal population of Karnataka and Kerala.

3. Objectives of the study

i To find if gender differences exist among normal to NFLD coronary artery dimensions.
ii To find the possible association of BMI with normal to NFLD coronary dimensions.

4. Materials and methods

A prospective cohort study was conducted for a period of one year. Two thousand angiograms samples (1000 cases per state) were collected from one centre each from the two south Indian states involved in the study after obtaining the ethical clearance. Convenience sampling was done as all eligible cases that fulfilled the inclusion criteria during the definied time period of the study were selected as samples. Patients were approached at the cath lab prior to angiogram procedure. Informed consent was obtained from patients involved in the study.

Patients who underwent coronary angiography procedure based on clinical indications were enrolled in the study if they were found to have either normal coronary arteries or only NFLD in the coronary arteries (up to 0–20% of stenosis in the branch vessels). Patients with previous history of myocardial infarction (MI) and recanalized normal looking coronary arteries were excluded. Patients with diabetes for five or more than five years regardless of having normal coronaries were also not included in the study.

Standard angiographic views[6–9]were obtained and quantitative coronary angiography (QCA) was carried out on longest possible disease-free segments of coronary arteries which were uniformly distended, contrast-filled and free of tortuosity or kinking without overlap. Right and left coronary artery and its main branch vessel morphology were measured from artery segments free from stenosis at ostium and proximal segment by the automated coronary analysis program of the Innova 2100 IQ Cath at an AW 4.4 workstation. The vessels were assessed in an end-diastolic frame. Patients with normal and NFLD coronary arteries were included for calibration assessment if the artery segments were free from stenosis on angiograms.

Ten different coronary artery segments were assessed for diameter measurement. Left main coronary artery (LMCA), ostial and proximal segments of left anterior descending (LAD) and ostial and proximal segments of left circumflex coronary artery (LCx) were assessed for left coronary artery segment analysis. Measurements of the first diagonal branch of LAD (DIAG), ramus intermedius (RI) and the obtuse marginal branch of LCx (OM) were taken from a point of maximum diameter near ostium. As on the left side, for the right coronary artery (RCA) also, ostial and proximal segments were measured. Patient's anthropometric measurements were obtained using the relevant equipment. BMI values were calculated by the relevant formula i.e. weight in kilograms divided by height in metres squared (kg/m^2) using patient's height and weight measurements. Statistical analysis was done using the SPSS software package for Windows version 22.0 (SPSS Inc., Chicago, IL). Mean ± standard deviation (STDEV) was used to express vessel dimensions. Independent *t*-test was used to compare the gender differences. Correlations were estimated by Pearson correlation coefficient. A p-value <0.005 was considered as statistically significant.

5. Results

Out of the 2000 patients included in the study, 454 (22.7%, mean age 53.4 ± 14.2 years) had normal to NFLD coronaries. Of these 454 patients, 253 (55.7%, mean age 51.5 ± 15.3 years) were males and 201 (44.3%, mean age 55.3 ± 13.2 years) were females (Table1). All segments of the coronary arteries taken for diameter measurements in the present study had increased diameter for males compared to females. The differences were statistically significant for eight segments but not for the OM branch of LCx and proximal RCA (Table 2).

Table 2
Gender-wise average diameters of coronary artery segments among the study subjects (n = 454).

Coronary artery segments	Men (N = 253)		Women (N = 201)		p-value
	N	Diameters	N	Diameters	
LMCA	250	4.29 ± 0.76	200	3.96 ± 0.73	**0.004**
LAD- ostium	251	3.25 ± 0.54	200	3.09 ± 0.58	**0.005**
LAD- proximal	252	3.24 ± 0.52	201	3.10 ± 0.58	**0.004**
DIAG	249	1.83 ± 0.43	197	1.65 ± 0.41	**0.001**
LCX- ostium	253	3.25 ± 0.63	198	2.96 ± 0.65	< **0.001**
LCX- proximal	252	3.11 ± 0.68	200	2.81 ± 0.61	< **0.001**
OM	248	2.19 ± 0.48	199	2.05 ± 0.41	**0.003**
RCA- ostium	251	3.32 ± 0.73	200	3.02 ± 0.73	**0.002**
RCA- proximal	252	3.06 ± 0.63	201	2.98 ± 0.61	0.319
Ramus intermedius	27	2.41 ± 0.59	25	2.16 ± 0.37	0.369

All diameter measurements are reported as mean ± standard deviation (mm).
LMCA - Left main coronary artery, LAD- Left anterior descending artery, DIAG - Diagonal branch of left anterior descending artery, LCx- Left circumflex coronary artery, OM - Obtuse marginal branch of left circumflex coronary artery, RCA- Right coronary artery.

Table 3
Body-mass index categorisation of study subjects based on criteria defined for Asian populations.

Categories	Total (n = 454)	Men (n = 253)	Women (n = 201)
Overall BMI (kg/m^2)*	23.3 ± 0.58	24.5 ± 0.55	22.1 ± 0.60
BMI categories			
Less than 18·5 kg/m^2 – Underweight, n (%)	97 (21.4)	54 (21.3)	43 (21.4)
18·5–23 kg/m^2 - Normal/ increasing but acceptable risk, n (%)	209 (46.0)	119 (47.0)	90 (44.8)
23–27·5 kg/m^2 - Overweight/ increased risk, n (%)	81 (17.8)	45 (17.8)	36 (17.9)
27·5 kg/m^2 or more - Obesity/ higher high risk, n (%)	53 (11.7)	26 (10.3)	27 (13.4)
Not assessed, n (%)	14 (3.1)	9 (3.6)	5 (2.5)

BMI- body-mass index.
* values represent mean ± standard deviation.

The distribution of study subjects according to BMI categories is provided in Table 3. An overall significant negative correlation was seen between BMI and diameters of nine coronary segments, except for RI (Table 4). This indicates that an increase in BMI is associated with a relative decrease in the coronary artery diameters. However, when analyzed separately for men and women, there was no significant correlation between any of the diameter measurements and BMI (Table 4).

6. Discussion

The primary finding of the present study is that coronary artery diameter is gender-specific with men having larger dimensions for various coronary artery segments as compared to women.

Gender is considered as a significant predictor of clinical characteristics and outcomes following coronary revascularization procedures.[10,11] Most of the previous studies which involved coronary artery diameter analysis had revealed that women had smaller coronary artery diameter compared to men.[12,13]

Gender-specific differences were observed in the coronary diameters in a retrospective data analysis by QCA among Iraqi Kurdish population. The male samples had larger diameters with a significant p-value for LMCA, proximal LAD, LCx and RCA than female samples.[14] Gender thus significantly influences diameter of the left and right main coronary arteries which may necessitate gender-specific approaches during PCI and coronary artery bypass grafting.[15] Differences in disease outcomes between women and men can be related to vascular biological factors such as smaller vessel size and functional differences of smooth muscle cells in the vessel wall. This can also be a cause for smaller atheroma burden in women.[16]

Gender significantly impacts proximal LAD and RCA size even after normalizing for body surface area (BSA) and cardiac mass. This can explain certain gender-related risks with coronary artery revascularization.[2] In a previous study, though having smaller coronary arteries dimensions was not a prevailing cause of higher 6-month mortality after PCI among women, but the decrease in target vessel size was associated with increased risk of restenosis and repeat revascularization.[17]

Women have higher age-related incidence and poor prognosis of MI, which may also be due to smaller coronaries compared to men.[18] However, these differences may not influence the likelihood of plaque progression or regression in them. To assess the extent and direction of arterial remodelling in vivo among individual lesions, it is necessary to compare vessel size at the lesion site to an adjacent reference site that contains the minimal disease. The new imaging modalities i.e., intravascular ultrasound have confirmed that plaque progression and regression are not closely related to luminal size.[19]

In the present study, we also found that when BMI increases there is a relative decrease in the coronary artery diameter. These findings are in contrast to some of the previous reports on this subject. Zeina et al[20] reported a significant correlation between LMCA cross-sectional area with height, weight, and body surface area among male samples. In another study, gender-specific and age-dependent significant correlation between RCA diameter and BMI among male samples were observed.[21] In contrast, Leung et al[22] reported no significant correlation of coronary artery dimensions with anthropometric measurements or with BSA. The reasons for smaller coronary dimensions with increasing BMI in our study are not clearly apparent. However, smaller coronary sizes

Table 4
Correlation of body mass index with coronary artery segment diameters in the study subjects.

Coronary segment	Total sample		Men		Women	
	r	P value	r	P value	r	P value
LMCA	−0.182	<**0.001**	−0.024	0.786	−0.1	0.259
LAD- ostium	−0.175	<**0.001**	0.035	0.683	−0.067	0.453
LAD- proximal	−0.178	<**0.001**	−0.056	0.515	−0.161	0.073
DIAG	−0.167	<**0.001**	−0.05	0.563	−0.073	0.416
LCX- ostium	−0.265	<**0.001**	−0.024	0.783	−0.067	0.455
LCX- proximal	−0.193	<**0.001**	0.003	0.971	−0.04	0.656
OM	−0.198	<**0.001**	0.095	0.727	0.166	0.607
RCA- ostium	−0.172	<**0.001**	0.016	0.859	−0.099	0.269
RCA- proximal	−0.110	**0.018**	−0.004	0.965	−0.134	0.132
Ramus intermedius	−0.107	0.415	−0.013	0.883	−0.098	0.27

LMCA - Left main coronary artery, LAD- Left anterior descending artery, DIAG - Diagonal branch of left anterior descending artery, LCx- Left circumflex coronary artery, OM - Obtuse marginal branch of left circumflex coronary artery, r- Pearson's correlation coefficient, RCA- Right coronary artery.

in subjects with higher BMI values may predispose them to increased risk of developing coronary artery disease.

7. Study limitations

Gender-associated clinical outcomes on target vessel after angioplasty were not assessed. Age- adjusted data would have enhanced the study results.

8. Conclusion

The present study indicates that men have higher caliber for coronary arteries compared to women. Coronary artery diameter is thus gender-specific. The study also indicates that when BMI increases there is a relative decrease in the coronary artery diameter.

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