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Original Article

Comparison of Visceral Adiposity Index with Other Indices of Adiposity in Patients with Acute Myocardial Infarction

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ABSTRACT

Background: Obesity continues to increase exponentially across the globe. BMI has been the traditional method used to define and quantify the severity of obesity. In recent years, visceral fat has emerged as an important measure of cardiovascular risk. Although MRI and CT scan can estimate the degree of visceral fat, these methods are not feasible in the routine clinical setting. Visceral Adiposity Index (VAI) is a recently derived index to measure visceral fat based on the knowledge of Waist Circumference (WC), plasma HDL, triglycerides and BMI. The study aimed to compare VAI with other adiposity indices in Acute MI and to also assess its ability to detect metabolic syndrome. **Methods:** In this cross-sectional study, 213 patients (Acute STEMI- 106, Controls-107) were included. The lipid profile and all other routine laboratory investigations were performed. Waist and hip circumference (HC) were measured. VAI and other adiposity indices were measured such as atherogenic index (AI), Conicity index (CI), Waist Hip Ratio (WHR) and Waist Height Ratio (WHtR) using appropriate formulae. **Results:** Patients with metabolic syndrome had higher VAI index (p=0.0001), higher AI index (p=0.0001), higher CI (p=0.0001), higher BMI (p=0.0001), higher WC (p=0.0001) and higher HC (p=0.0001). An ROC curve plotted for each adiposity index to detect metabolic syndrome showed VAI to have the maximal AUC. A VAI of 2.69 was chosen as the cut-off value which had a sensitivity of 70.1% and specificity of 74.35 % (AUC=0.81, CI-0.74 to 0.87; P=0.0001). **Conclusion:** VAI is an excellent and simple tool to detect Mets as compared to other adiposity indices. It remains to be seen if VAI could accurately reflect the degree of cardiovascular risk from prospective cohort studies.

Key words: Acute Myocardial Infarction, Anthropometric indices, Atherogenic Index, Metabolic syndrome (Mets), Visceral Adiposity index, Waist circumference.

INTRODUCTION

Obesity is an important risk factor for cardiovascular disease and is an increasing pandemic across the globe.[1] Although BMI has traditionally been the standard index to classify and define obesity; in recent years increasing importance has been given to other indices of adiposity such as waist circumference, waist hip ratio, waist height ratio, atherogenic index, body adiposity index. Measurement of the degree of visceral fat has become an important determinant of the degree of cardiovascular risk.[2] The gold standard assessment method for the estimation of visceral fat content has been Magnetic resonance imaging and Computerized tomography. However these methods are not pragmatic owing to the cost and time involved in their utilization.[3] Visceral adiposity which is mainly aggregation of unwanted fats in the abdominal region is known to rise steadily as age advances in both genders.[4] A study concluded that association between visceral fat and BMI was only frugal and visceral adiposity was able to stratify cardiovascular risk across BMI.[5] The Visceral adiposity index has been a recently derived score that has been adjusted for gender which can be assessed with the knowledge of the patient's waist circumference and the triglyceride levels. Studies have used the visceral adiposity index using the formula derived by Amato *et al*,[6] in different populations such as women with PCOS,[7,8] patients population with NAFLD,[9-14] patients with HCV,[15] patients with acromegaly,[16,17] patients with prolactinoma,[18] patients with diabetes[19,20] and general population without Metabolic syndrome.[21-24] However there are limited studies that have used visceral adiposity index in patients with myocardial infarction. The values of visceral adiposity index in comparison with other indices of adiposity such as WC, WHR, WHtR and AI have not been previously explored.

The aim of the study is to compare the visceral adiposity index in patients with MI and age and gender matched controls and to also

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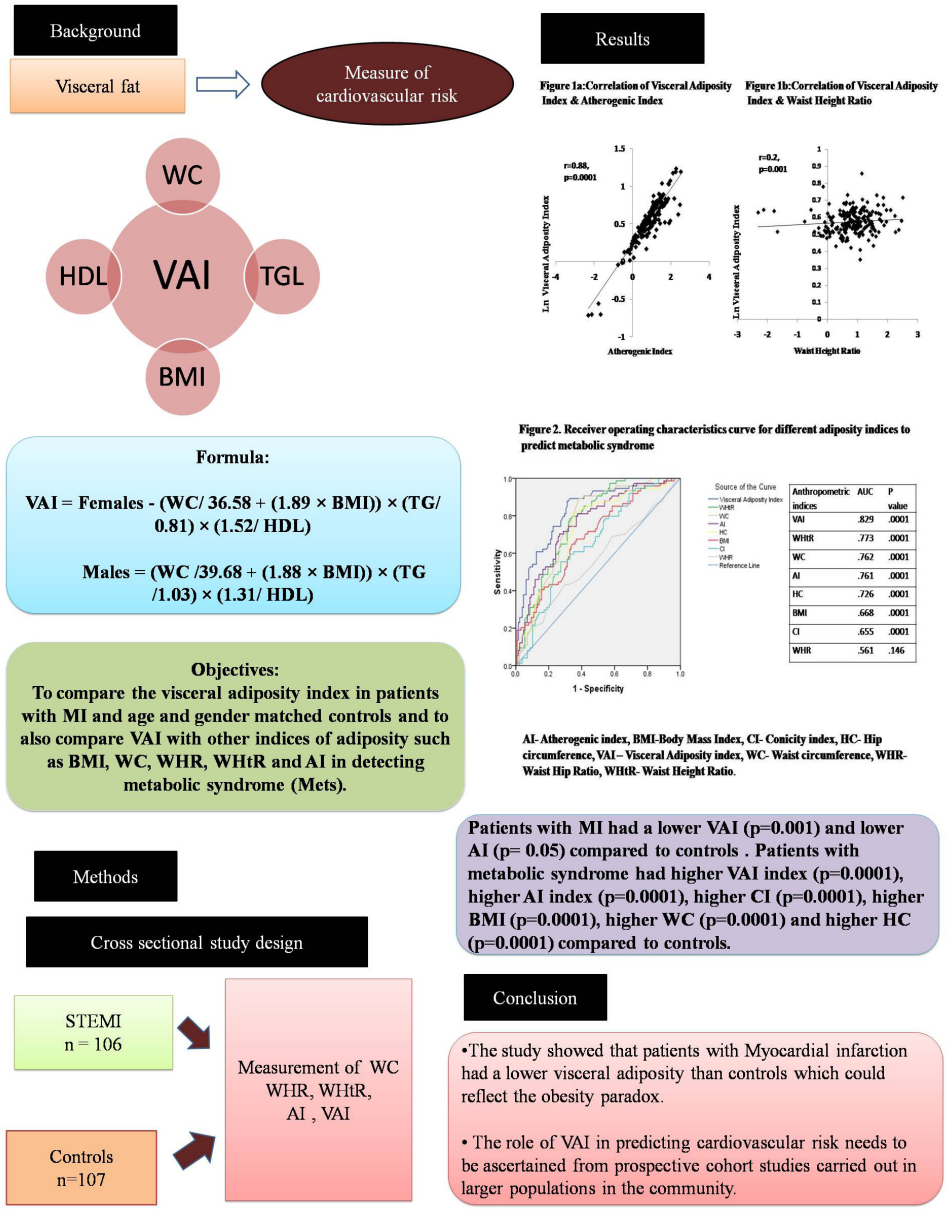


Graphical Abstract

compare VAI with other indices of adiposity such as BMI, WC, WHR, WHtR and AI in detecting metabolic syndrome (Mets).

METHODOLOGY

The study was a prospective cohort study performed in the Dept of Cardiology at SRM Medical College Hospital & Research Centre, Kattankulathur, Kancheepuram, Tamil Nadu, India between May 2013 to November 2014. The study was approved by the Institute Ethics Committee of SRM Medical College Hospital. We included patients admitted with a diagnosis of Acute ST Elevation Myocardial Infarction as diagnosed by symptoms, ST segment elevation in contiguous leads and elevated cardiac biomarkers and who presented to the hospital within 48 hours of onset of symptoms and who were willing to give informed consent. The control population included patients presenting to the hospital with any other diagnosis apart from myocardial infarction such as unstable angina or non ST elevation, Dilated Cardiomyopathy, Atrial Septal Defect, Hypertension with atypical chest pain. The waist circumference was measured as the midpoint between the lower margin of the lowest rib and the upper portion of the iliac crest. Hip circumference was measured with the tape wrapped around the maximum circumference of the buttocks.[25] All demographic data of the study patients was recorded from the patient records. The visceral adiposity index was calculated using the formula-Females: VAI=(WC/ 36.58 + (1.89 × BMI) × (TG/ 0.81) × (1.52/ HDL). and males VAI=(WC /39.68 + (1.88 × BMI)) × (TG /1.03) × (1.31/ HDL).[6] The Atherogenic index was calculated using the formula log (TG/HDL-C).[26] The conicity index was calculated using the formula Conicity index = waist circumference (m) /√0.109 ((√weight (kg)/height (m).[27] The waist hip ratio and the waist height ratio were also measured.

Statistical analysis

Baseline characteristics of all the patients were presented by mean ± SD in case of continuous variables and categorical variables were represented in percentages. Chi square test was used for comparing categorical variables and Student t test was used for comparing continuous variables. The anthropometric indices of obesity were compared between MI and Non-MI patients using t test or Mann Whitney test. Patients with and without metabolic syndrome were compared with respect to the different variables using student's t

Table 1: Baseline Characteristics of study patients

Risk factors	Non MI	MI	P value
Age	55.36 ± 11.04	55.52 ± 10.78	0.91
Gender	69 (64.5%)	89 (84.0%)	0.00
Height	157.95 ± 9.05	160.75 ± 8.41	0.02
Weight	64.80 ± 11.45	67.24 ± 10.59	0.11
BMI	24.30 ± 7.71	25.07 ± 6.29	0.42
WC	90.96 ± 11.41	91.91 ± 9.78	0.51
HC	93.60 ± 10.87	93.88 ± 9.54	0.83
WHR	0.97 ± 0.06	0.98 ± 0.06	0.44
Urea	28.93 ± 17.12	28.70 ± 16.07	0.92
Creatinine	1.20 ± 0.95	1.1 3± 0.56	0.50
Hb	12.73 ± 2.01	13.76 ± 2.15	0.00
TC	172.49 ± 56.67	183.60 ± 47.98	0.12
HDL	37.67 ± 20.21	40.52 ± 26.92	0.38
LDL	107.20 ± 51.53	119.36 ± 42.88	0.06
VLDL	34.44 ± 22.91	30.15 ± 19.62	0.14
TGL	152.93 ± 79.42	136.45 ± 68.68	0.10
DM	62 (57.9%)	51 (48.1%)	0.21
HT	58 (54.2%)	53 (50.0%)	0.58
Smoking	29 (27.1%)	39 (36.8)	0.13
Alcohol	25 (23.4%)	35 (33.0%)	0.08
SL	20 (18.7%)	23 (21.7)	0.48
LVEF	53.46 ± 13.28	47.44 ± 11.54	0.00
VAI	3.27 ± 2.23	2.47 ± 1.511	0.00

BMI- body mass index, WC- waist circumference, HC- hip circumference, WHR- waist hip ratio, Hb- haemoglobin, TC- total cholesterol, HDL- high density cholesterol, LDL- low density cholesterol , VLDL- very low density cholesterol, TGL- triglycerides, DM- diabetes mellitus, HT- hypertension, SL- sedentary lifestyle, LVEF- left ventricular ejection fraction.

Table 2: Anthropometric indices of adiposity in study patients

Anthropometric indices	Non-MI	MI	P value
Visceral Adiposity Index	3.27 ± 2.23	2.47 ± 1.51	0.00
BAI	724.86 ± 88.22	721.60 ± 75.76	0.77
AI	0.58 ± 0.28	0.50 ± 0.27	0.05
WHR	0.97 ± 0.06	0.98 ± 0.06	0.44
WHtR	0.57 ± 0.07	0.57 ± 0.06	0.58
CI	1.30 ± 0.11	1.30 ± 0.10	0.91
BMI	24.30 ± 7.71	25.07 ± 6.29	0.34
WC	90.96 ± 11.41	91.91 ± 9.78	0.51
HC	93.60 ± 11.41	93.88 ± 9.54	0.08

BMI- body mass index, WC- waist circumference, WHR- waist hip ratio, WHtR- waist height ratio, AI – atherogenic index, VAI-Visceral Adiposity Index.

test or Mann Whitney test. Those variables which followed a skewed distribution were log transformed prior to analysis. Pearson correlation was used for correlation of VAI with other indices of adiposity. A p value of less than 0.05 was considered as statistically significant. Data were analyzed using SPSS ver.16.0.

RESULTS

The study included 213 patients of which 106 belonged to the STEMI group and 107 belonged to the control group. The baseline characteristics of the study patients are shown (Table 1). Patients with myocardial infarction had lower left ventricular ejection fraction (p=0.001) ,higher percentage of males (p=0.001) , higher hemoglobin (p=0.001) and greater predisposition to alcohol use (0.001) than the control population.

The anthropometric indices of adiposity were calculated between both the study groups (Table 2). Patients with MI had a lower Visceral adiposity Index (p=0.001) and lower atherogenic index (p=0.05). There was no difference in other adiposity indices between the two

Table 3: Anthropometric indices in patients with and without metabolic syndrome

Risk Factors	Patients With MetS	Patients Without MetS	P value
Age	56.87 ± 10.53	54.63 ± 11.04	0.15
Urea	28.27 ± 14.66	29.12 ± 17.61	0.72
Creatinine	1.15 ± 0.62	1.17 ± 0.86	0.82
Hb	12.86 ± 2.05	13.47 ± 2.16	0.05
TC	180.74 ± 49.25	176.48 ± 54.66	0.57
HDL	35.12 ± 8.50	41.33 ± 28.86	0.06
LDL	115.50 ± 43.55	111.98 ± 50.01	0.60
VLDL	36.90 ± 17.55	29.75 ± 22.89	0.02
TGL	183.42 ± 79.84	122.82 ± 61.66	0.0001
LVEF	50.05 ± 11.29	48.64 ± 12.33	0.43
Visceral Adiposity Index	4.05 ± 2.28	2.21 ± 1.34	0.0001
AI	0.69 ± 0.20	0.46 ± 0.28	0.0001
WHR	0.98 ± 0.07	0.97 ± 0.06	0.16
WHtR	0.61 ± 0.05	0.55 ± 0.06	0.0001
CI	1.34 ± 0.07	1.28 ± 0.12	0.0001
BMI	26.76 ± 6.80	23.51 ± 6.92	0.0001
WC	96.64 ± 7.62	88.49 ± 10.96	0.0001
HC	98.40 ± 9.43	91.10 ± 9.70	0.0001

BMI- body mass index, WC- waist circumference, HC- hip circumference, WHR- waist hip ratio, Hb- haemoglobin, TC- total cholesterol, HDL- high density cholesterol, LDL- low density cholesterol , VLDL- very low density cholesterol, TGL- triglycerides, DM- diabetes mellitus, HT- hypertension, SL- sedentary lifestyle, LVEF- left ventricular ejection fraction, VAI-Visceral Adiposity Index.

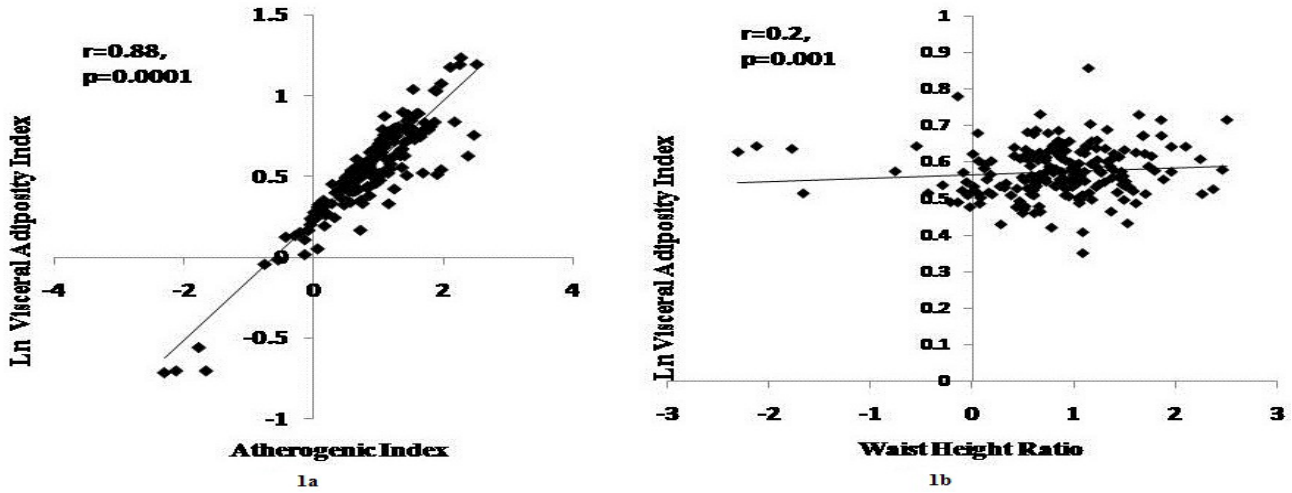
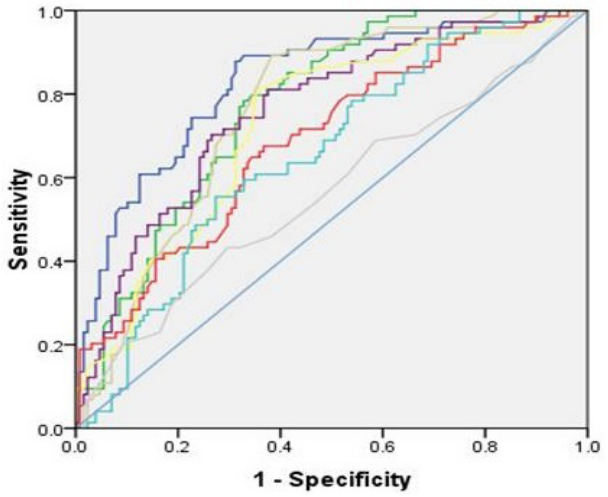


Figure 1a: Correlation of Visceral Adiposity Index and Atherogenic Index. 1b: Correlation of Visceral Adiposity Index and Waist Height Ratio

study groups. We divided the patients population based on the presence or absence of a particular risk factor such as diabetes, hypertension, smoking, sedentary lifestyle. Diabetic patients had a higher a VAI than non diabetic patients. (Data not displayed) There was no difference in VAI when comparison was made for other risk factors.

We also classified patients as those with or without Metabolic Syndrome based on the IDF criteria. Patients with metabolic syndrome had higher VAI index (p=0.0001), higher AI index (p=0.0001), higher CI (p=0.0001), higher BMI (p=0.0001), higher WC (p=0.0001), higher HC (p=0.0001). (Table 3)

We performed a Pearson's correlation between VAI and other indices of adiposity. (Figure 1) There was a significant correlation between VAI and atherogenic index (r=0.88, p=0.0001), VAI and WHtR (r=0.2,p=0.003) We also plotted an ROC curve to find the cut-off value for VAI index that would accurately predict the presence of MetS (Figure 2). A VAI of 2.69 was chosen as the cutoff value which



Anthropometric indices	AUC	P value
VAI	.829	.0001
WHtR	.773	.0001
WC	.762	.0001
AI	.761	.0001
HC	.726	.0001
BMI	.668	.0001
CI	.655	.0001
WHR	.561	.146

Figure 2: Receiver operating characteristics curve for different adiposity indices to predict metabolic syndrome

AI-Atherogenic index, BMI- body mass index, CI- Conicity index, HC- hip circumference, VAI-Visceral Adiposity Index, WC- waist circumference, WHR- waist hip ratio, WHtR- waist height ratio.

had a sensitivity of 70.1% and specificity of 74.35% (AUC=0.81, CI-0.74 TO 0.87; P=0.0001).

DISCUSSION

Our study showed that patients with MI had a lower VAI than those without MI. This is in contrast to earlier studies that have shown that patients with increased VAI had a greater cardiovascular risk. For instance, Zhang *et al* in his nested case control study estimated the risk for CHD in a non western population. Patients with elevated triglycerides and waist circumference were termed as hypertriglyceridemic waist phenotype. Hypertriglyceridemic waist phenotype was more prone to cardiometabolic risk in both men and women. VAI also showed a very substantial association with CHD risk in the study.[24] Visceral adiposity was also measured by determining the visceral fat content with CT scan. In a hospital based, case control study performed in young patients with coronary artery disease, the visceral fat was much higher in CAD patients than from the controls.[28] In a cross sectional study where patients were drawn from the participants in the Framingham Heart Study Offspring cohort who underwent abdominal and chest multi detector computed tomography to estimate pericardial fat, intra thoracic fat, and VAT. The result of the study showed that pericardial fat and VAT were having significant association with CVD in age- and sex-adjusted models which continued to be the same after adjustment for BMI and WC.[29] Although these studies clearly show that VAI is a good predictor of cardiovascular risk, it is intriguing that in our study we did not observe these findings. This could possibly be explained by the obesity paradox that has been documented in several earlier studies. In a meta-analysis that included 26 studies and 2,18,532 patients with ACS, low BMI were associated with highest risk of mortality. Lower mortality was seen in overweight, obese and severely obese patients BMI when compared with healthy controls[30] It is also possible that patients with MI had more intensive physical activity than controls due to their awareness of their predisposition to cardiovascular disease on account of the risk factor status. Nevertheless in the light of the fact that most studies showing that increased visceral adiposity to portend a greater cardiovascular risk, this finding of our study begs further explanation.

The study also showed that patients with visceral adiposity index greater than 2.69 could fairly predict MetS. In fact among all the adiposity indices VAI was the best predictor of MetS. These findings are consistent with data from an earlier published study in the Caucasian Sicilian population. Patients were divided into five age groups and a cut-off to predict MS for each of these groups was identified. Those patients in the age group between 52-65, which was the group most similar to our population in age, had a VAI cut off of 1.93 to predict Mets.[22] In a study performed in post menopausal women in Ghana, atherogenic indices such as TG/HDL and HDL/TC were most predictive of metabolic syndrome. However the WC and WHR were not able to successfully predict metabolic syndrome.[31] Even the study by Knowles et al in Peruvian patients showed that none of the adiposity indices had any superiority over each other in detecting Mets. However VAI, WC and WHtR were the best predictors of individual components of Mets.[23]

We also found that patients with diabetes had a higher VAI than non diabetic patients. Bozorgmanesh et al observed that as VAI increased, the risk of diabetes also increased proportionately. Although VAI was also shown to have a strong correlation with fasting insulin in an earlier study, even other measures such as WC and BMI had similar strong correlations with VAI.[20] Since we did not measure insulin in our study this relationship could not be ascertained. Nevertheless, there was no difference between diabetes and non diabetes as far as other parameters of adiposity were concerned in our study. Our findings do suggest that greater the visceral adiposity more would be the amount of insulin resistance.

The main limitation of our study was that it was a cross sectional study and hence the ability of VAI to predict future cardiovascular disease could not be accurately predicted. Inspite of this, VAI clearly showed to have a greater ability than other adiposity indices in detecting metabolic syndrome. There could also be a selection bias in our study since the sample chosen was from the hospital and not a random sample from the population.

CONCLUSION

Visceral adipose tissue has gained tremendous significance in recent years as an endocrine organ. Our study showed that patients with Myocardial infarction had a lower visceral adiposity than controls which could reflect the obesity paradox. The role of VAI in predicting cardiovascular risk needs to be ascertained from prospective cohort studies carried out in larger populations in the community.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

ABBREVIATIONS

BMI: Body Mass Index, VAI: Visceral Adiposity Index

PCOS: Polycystic ovary syndrome

WC: Waist Circumference, HC: Hip Circumference
WHR: Waist Hip Ratio
Hb: Haemoglobin
TC: Total cholesterol
HDL: High density cholesterol
LDL: Low density cholesterol
VLDL: Very low density cholesterol
TGL: Triglycerides
DM: Diabetes mellitus
HT: Hypertension
SL: Sedentary lifestyle,
LVEF: Left ventricular ejection fraction,
NAFLD: Non-alcoholic fatty liver disease
HCV: Hepatitis C virus
AI: Atherogenic index
IDF: International Diabetes Federation

Highlights of Paper

- Visceral adiposity is mainly the accumulation of unwanted fats in the abdominal region which increases as age advances in both the genders.
- The Visceral adiposity index has been a recently derived score that has been adjusted for gender which can be assessed with the knowledge of the patient's waist circumference, triglyceride levels, BMI and HDL.
- In Patients with MI, VAI was lower than those without MI and patients with diabetes had a higher VAI than non diabetic patients.
- Visceral adiposity index greater than 2.69 could fairly predict MetS.

Author Profile

- **Dr. Vengatesh Munusamy:** is currently working as Associate professor in the Dept of Cardiology at SRM Medical College Hospital, Kattankulathur, Kancheepuram. He completed his DM in Cardiology from Stanley Medical College and has more than ten years service as a cardiologist. His area of expertise includes clinical cardiology and transthoracic echocardiography. He is currently a principal investigator of an international phase 3 clinical trial with a novel drug that can potentially reduce major adverse cardiovascular events following a myocardial infarction. His research interests include biomarkers in relation to cardio-metabolic disease.

- **Dr Melvin George:** presently working as Assistant Professor, Cardiac Clinical Trials & Research, Dept of Cardiology at SRM Medical College Hospital, Kattankulathur, Kancheepuram. He has published 19 papers (both original and review articles) in peer reviewed international and national journals and has presented research papers at various national conferences. His research interests include cardiovascular biomarkers, dyslipidemia, obesity and diabetes. He is a member of the institute ethics committee in SIMS Hospital, Chennai. He is also involved as a co-investigator in two international phase 3 clinical trials on new cardiovascular drugs.

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