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ORIGINAL ARTICLE

To Evaluate Efficiency of Various Coronary Artery Disease Risk Scores With Traditional Risk Factors in Patients Undergoing Coronary Angiography

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Abstract

Objective: **To analyze and compare various cardiovascular disease risk scores in Western Indian patients undergoing Coronary angiogram (CAG).**

Methods: **In this prospective cross-sectional study, 1213 patients who underwent conventional coronary angiography; clinical risk profile and biochemical investigations were evaluated prior to undergoing CAG. Apart from the demographic information, 10-year absolute risk of having a major cardiovascular event (cardiovascular death, myocardial infarction or stroke) was calculated for each patient using various available Traditional Risk Scores (TRS). The population was divided in low, intermediate and high-risk categories for each of these scores.**

Results: **Traditional cardiovascular risk factors like hypertension (41.8%) and diabetes mellitus-II (26.9%) were the two most prevalent risk factors in our study population. A higher risk value for all these TRS was more likely to be associated with obstructive coronary artery disease (OCAD) on CAG. Patients with high risk (≥20% for 10-year) QRESEARCH (QRISK3) score category had higher number of patients with obstructive CAD (49.6%) as compared to high risk category of risk score for those with high Global Registry of Acute Coronary Events (GRACE) score (46.6%) or risk Framingham (FRS CHD) score (29.2%) and risk atherosclerotic cardiovascular disease (ASCVD) score (30.1%) ($P < 0.0001$). A higher TRS was more likely to be associated with obstructive CAD, with the highest predictability being with QRISK3 (QRISK3 score 60.9%, GRACE score 54.9%, FRS-CHD score 34% and ASCVD score 42.1% respectively; $P < 0.0001$). A substantial study population (27.4%) cannot be identified using any of these TRS and hence a need of indigenous or modified risk scores is proposed.**

Conclusion: **QRISK3 score was most efficacious for predicting obstructive CAD in our Indian study population on CAG. A higher risk score also correlated with the number of vessels involved on coronary angiogram. A substantial obstructive CAD patient could not be identified using traditional risk scores hence need for an indigenous or modified score.**

Keywords: Coronary angiography, Coronary artery disease, Risk stratification, Risk score model

1. Introduction

Coronary artery disease (CAD) is one of the major causes of death worldwide and is an important indication of cardiovascular disease (CVD) [1]. The Indian population exhibits a unique set of risk factors contributing to CAD development. These include genetic predisposition, lifestyle choices, cultural practices, and dietary habits. By understanding the interplay between traditional risk

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factors such as hypertension, diabetes mellitus-II, smoking, unfavorable blood lipid levels, negative psychological factors, alcohol consumption, obesity we can grasp the complexity of CAD risk in India [2]. Consequently, numerous cardiovascular disease risk assessment instruments have been formulated to predict the 10-year likelihood of experiencing a fatal or non-fatal cardiovascular event in adults, irrespective of their pre-existing cardiovascular disease status [3].

The rising prevalence of CAD in India demands a comprehensive understanding of risk prediction models. By exploring the strengths, limitations, and recommendations of existing Traditional risk score (TRS) calculators, we can enhance the accuracy and relevance of CAD risk assessments in our population [4]. The primary goal of this study was to assess, analyse and compare various cardiovascular TRS. We intended to compare various traditional risk scores to measure and compare 'at risk' prediction in Western Indian patients who were undergoing Coronary angiogram (CAG) by calculating their Framingham risk score (FRS-CHD), the American College of Cardiology Foundation and American Heart Association (ACC/AHA)- atherosclerotic cardiovascular disease (ASCVD) risk score, the QRESEARCH (cardiovascular risk algorithm) estimated version 3 (QRISK3 score), the Global Registry of Acute Coronary Events (GRACE) risk score, and the Selecting Patients Of Rheumatic Heart Disease Undergoing Valve Surgery For Presurgical Coronary Angiography (SERENE-CAG) risk scores.

Abbreviations

CAD	Coronary artery disease
CAG	Coronary angiogram
TRS	Traditional risk scores
OCAD	Obstructive coronary artery disease
FRS-CHD	Framingham risk score
ACC/AHA	American college of cardiology foundation and American heart association
ASCVD	Atherosclerotic cardiovascular disease
QRISK3	QRESEARCH cardiovascular risk algorithm;
GRACE	Global registry of acute coronary events
SERENE-CAG	Selecting patients of rheumatic heart disease undergoing valve surgery for presurgical coronary angiography
ARA	Angina related artery
ROC	Receiver operator characteristics curve
AUC	area under curve

2. Materials and methods

2.1. Study population

This prospective, cross-sectional study was conducted in the department of Cardiology between November 2018 to December 2020 at the largest tertiary cardiac institute of Western India. 1213 hospitalised patients who were to undergo conventional coronary angiography were enrolled and assessed for their 10-year risk using all the above mentioned traditional risk scores. The severity of artery stenosis was determined using Two-Dimensional System Quantitative Coronary Analysis (CAAS II QCA) Research version 2.0.1 Software (Pie Medical Imaging). Patients who had 50% stenotic lesion(s) in any one or more of the major epicardial coronary arteries or their major branches was considered as obstructive CAD(OCAD). Non-obstructive CAD was considered if there was less than 50% stenosis or plaque in one or major coronary arteries or their branches. Assessment of angiographic lesion severity was done by stenosis in culprit angina related artery (ARA). The study protocol was approved by our institutional ethics committee (18th November 2018/14). Written informed consent was taken from all the participants. All authors declare that all supporting details are available within the cited articles. No AI tools were used to prepare this manuscript content.

2.2. Study design

This was a prospective, all-comer study. The study included individuals aged 18–74 years who were admitted for coronary angiography. All subjects were evaluated for clinical and biochemical investigations. Physical evaluation includes measurement of height, weight and blood pressure measurement and the examination of CV system. Apart from traditional risk scores estimation with all the mentioned tools, clinical evaluation including past history of CV risk factors, family history and symptoms were captured. Fasting lipid profiles, fasting and 2-hour post-prandial blood glucose, serum creatinine, trop-I, and CPK-MB levels were also measured as part of the biochemical investigations.

Exclusion criteria for traditional risk scores was defined according to risk score calculations used in the previous defining studies. Patients with less than 40 years were excluded from ASCVD risk score calculation cohort analysis, while less than 30 years were excluded from FRS score calculation and age less than 25 years were excluded from QRISK3 score calculation.

2.3. Methods for risk score calculation

Apart from the demographic information collected, 10-year risk of having a major CV event (CV death, MI or stroke) was calculated for each patient for traditional risk scores using Risk-FRS, Risk-QRISK3, and Risk-ACC/AHA, absolute values for Risk-GRACE, and SERENE-CAG risk score calculator.

With FRS, patients were defined at low risk when the 10-year risk of events was ≤10%, intermediate risk when the risk was between 10% and 20%, and high risk when the estimated risk was ≥20%. Similar risk categories were defined for ASCVD and QRISK3 scores as defined in their original studies.

However, as Risk ACC/AHA limit 10-year risk estimation only to the individuals more than 40 years of age, and those up to 74 years of age; ASCVD risk score could be calculated in 1152 patient with 61 patients getting excluded from analysis for it due to age (<40 or >74 years) and for QRISK3 calculation of which 5 patients were excluded because of age being <25 years. FRS-CHD, GRACE and SERENE CAG risk score were calculated in all remaining 1213 patients. All the Risk calculation including FRS, QRISK3, GRACE, ACC/AHA score calculators are available online [5,6].

https://www.framinghamheartstudy.org/fhs-risk-functions/cardiovascular-disease-10-year-risk/.

https://clincalc.com/Cardiology/ASCVD/PooledCohort.aspx [7].

https://www.qrisk.org/ [8].

https://www.mdcalc.com/grace-acs-risk-mortality-calculator.

SERENE-CAG score being an Indian TRS was calculated using formula as proposed by Sharma et al. [9].

SERENE-CAG score = 0.665−0.00237 × SBP-0.000118 × DBP- 0.8582 × diabetes status − 0.00307 × HR+0.0567 × AGE (yrs.)

Using these risk assessment models (QRISK3, FRS-CHD, ASCVD SCORE), 10-year absolute CV risk estimates were derived and categorised in to the low, intermediate and high risk categories depending on <10%, 10−19.9% and >20% risk respectively.

All these five traditional risk scores measured prior to coronary angiography were calculated and analysed by receiver operator characteristics curve (ROC) and a cut off value were derived for yielding equal sensitivity and specificity for their ability to predict CAD on the coronary angiography in these Western Indian population undergoing coronary angiography.

2.4. Statistical analysis

All statistical analysis was performed using SPSS v 26.0 (Chicago, IL, USA). The comparisons among different groups were performed using Chi-square test for categorical variables and one-way analysis of variance for continuous variables. Continuous variables were summarized as mean ± standard deviation. Pearson's correlation analysis was used to assess the relationship between the coronary artery disease and various risk scores. Receiver operator characteristics analysis was performed to determine a cut-off point for risk scores that provides an approximately equivalent sensitivity and specificity for predicting coronary artery disease. Student's t-test was applied to find correlation of low v/s high risk score values with angiographic severity. Group differences associated with a p value ≤ 0.05 were considered statistically significant.

3. Results

The study included 1213 participants, predominantly male (76.3%), with an average age of 55.7 ± 10.8 years. Clinical profile and demographic details are mentioned in Table 1. Most prevalent traditional CV risk factor in these patients was hypertension (41.8%), followed by type-II diabetes mellitus (26.9%), and tobacco consumption (38.2%). Acute coronary syndrome (ACS) was diagnosed in 74% of the participants of which 41% were STEMI and 33% were NSTEMI/UA while 21% had chronic stable angina in this study. The population was categorized based on coronary angiography into non-obstructive (N = 400) and obstructive coronary artery disease (OCAD) groups (N = 813), with the latter defined by 50% stenosis in major coronary arteries or their major branches.

Significantly more abnormal values of lipid profiles and cardiac biomarkers like Trop-I, CPK-MB were noted in the obstructive CAD group (P < 0.0001).

Angiographic profile of patients with coronary angiography:

Angiography in 33% revealed normal coronary arteries, while obstructive CAD was observed in remaining 67%, with the left anterior descending artery(LAD) being the most affected. Patterns of disease included single vessel (29.1%), double vessel (18.5%), triple vessel (19.4%) while left main coronary artery was affected in 5.3% of study population.

OCAD patients were generally older, more likely to consume tobacco and were diabetics (P < 0.0001, 0.0001 and < 0.0001 respectively). Male gender

Table 1. Clinical characteristics of the study according to presence or absence of coronary artery disease.

Variables	Non-obstructive CAD N = 400(%)	Obstructive CAD N = 813(%)	Total N = 1213	P-value
Male	272(68)	654(80.4)	926(76.3)	**<0.0001**
Female	128(32)	159(19.6)	287(23.7)	
Age	52.28 ± 11.26	57.37 ± 10.18	55.69 ± 10.81	**<0.0001**
BMI	25.92 ± 5.06	25.32 ± 4.17	25.52 ± 4.49	**0.04**
Effort angina	164(41)	99(12.2)	263(21.7)	**<0.0001**
Unstable angina/NSTEMI	142(35.5)	258(31.7)	400(33)	0.19
STEMI	50(12.5)	447(55)	497(41)	**<0.0001**
Arrhythmias	17(4.3)	22(2.7)	39(3.2)	0.18
Dyspnea	43(10.8)	47(5.8)	90(7.4)	**0.004**
ST elevation on ECG	243(60.8)	748(92)	991(81.7)	**<0.0001**
Systolic BP	133.02 ± 19.48	130.34 ± 45.46	131.22 ± 38.87	0.15
Diastolic BP	81 ± 10.64	80.04 ± 10.43	80.36 ± 10.51	0.14
Killip class				
NA	35(8.8)	21(2.6)	56(4.6)	**<0.0001**
Class-I	351(87.8)	710(87.3)	1061(87.5)	0.91
Class-II	8(2)	33(4.1)	41(3.4)	0.09
Class-III	4(1)	45(5.5)	49(4)	**0.0003**
Class-IV	2(0.5)	4(0.5)	6(0.5)	0.68
Previously PCI	18(4.5)	66(8.1)	84(6.9)	**0.01**
CRF	7(1.8)	16(2)	23(1.9)	0.79
AF	20(5)	1(0.1)	21(1.7)	**<0.0001**
Smoker	127(31.8)	336(41.3)	463(38.2)	**0.0001**
Diabetes mellitus-II	66(16.5)	260(32)	326(26.9)	**<0.0001**
Hypertension	155(38.8)	352(43.3)	507(41.8)	0.13
Family history of Angina	55(13.8)	186(22.9)	241(19.9)	**<0.0001**
Ejection fraction (EF)	47.81 ± 10.31	42.57 ± 9.62	44.30 ± 10.15	**<0.0001**
Troponin-I	1553.67 ± 6710.43	9685.05 ± 21,241.5	7003.64 ± 18,213.73	**<0.0001**
CPK-MB	34.85 ± 44.02	89.2 ± 139.73	71.28 ± 119.88	**<0.0001**
Blood Sugar	125.95 ± 67.08	155.96 ± 88.59	146.06 ± 83.3	**<0.0001**
Serum creatinine	0.95 ± 0.4	1.03 ± 0.4	0.99 ± 0.4	**0.04**
Total cholesterol	166.01 ± 28.05	189.74 ± 38.9	181.9 ± 37.38	**<0.0001**
HDL	41.12 ± 9.36	38.10 ± 13.21	39.1 ± 12.16	**<0.0001**
LDL	101.89 ± 22.85	126.63 ± 29.66	118.47 ± 29.94	**<0.0001**

BMI-Body mass index; NSTEMI-Non-ST elevation myocardial infarction; STEMI-ST elevation myocardial infarction; ECG-Electrocardiogram; BP-Blood pressure; PCI-Percutaneous coronary intervention; CRF-Chronic renal failure; AF-Atrial fibrillation; CPK-MB-Creatine kinase-myoglobin binding; HDL-High density lipoprotein; LDL-Low density lipoprotein.

(80.4%), a family history of CAD or previous percutaneous coronary intervention (22.9%), and lower ejection fraction (42.6 ± 9.6%) were more likely to have obstructive CAD (P < 0.0001, 0.001 and < 0.0001).

Higher TRS values correlated with obstructive CAD on coronary angiography. The mean difference between these scores was statistically significant between patients with obstructive and non-obstructive CAD (Table 2). Among the TRS evaluated, QRISK3 was most efficient to identify patients at high cardiovascular (CV) risk (≥20% 10-year risk) and associated with obstructive CAD (403/813 = 49.6%) with Pearson's correlation of 0.34 (95% CI 0.26 to 0.36; P < 0.0001), outperforming other scores like GRACE (379/813 = 46.6%), FRS CHD (237/813 = 29.2%, and ASCVD (245/813 = 30.1%). This suggests that the latter scores may underestimate high CV risk in our population.

The 10-year CV risk estimates derived using all these TRS showed linear correlation with the extent of obstructive CAD (Single vessel vs triple vessel/left main coronary artery disease) with increasing TRS scores. Risk QRISK3, ASCVD and FRS-CHD score have traditionally given 10-year risk of developing CVD, while GRACE and SERENE-CAG have not been assessed in previous studies to estimate 10-year risk estimation. Higher scores in our study were associated with patients who had obstructive CAD on angiography (P < 0.0001).

Notably, FRS-CHD uses 20% as cut off to start statin, so it could identify only 23% of patient's as statin eligible. Further ASCVD, with the decision threshold of 7.5% could identify only 59% of patient in this study as statin eligible. QRISK3 was the most effective in categorizing patients (66%) for statin eligibility based on the 10-year CV risk estimates showing a correlation with the extent of obstructive CAD.

Patients were classified into low, intermediate, and high risk categories based on 10-year CV risk

Table 2. Estimated 10 Year CV risk score according to presence or absence of CAD.

Risk score	Non-obstructive CAD N = 400(%)	Obstructive CAD N = 813(%)	Total N = 1213	P-value
QRISK3 (N = 1208)				
Mean score ±SD	12.8 ± 13.14	22.13 ± 14.25	19.08 ± 14.01	**<0.0001**
Patients with <20% 10-year risk, n (%)	304(77)	410(50.4)	714(59.1)	**<0.0001**
Patients with ≥20% 10-year risk, n (%)	91(23)	403(49.6)	494(40.9)	**<0.0001**
GRACE (N = 1208)				
Mean score ±SD	109.12 ± 32.86	138.83 ± 25.23	129.11 ± 31.23	**<0.0001**
Patients with <20% 10-year risk, n (%)	333(83.3)	434(53.4)	767(63.2)	**<0.0001**
Patients with ≥20% 10-year risk, n (%)	62(15.5)	379(46.6)	441(36.4)	**<0.0001**
FRS CHD(N = 1213)				
Mean score ±SD	7.55 ± 7.36	13.16 ± 8.22	11.31 ± 8.37	**<0.0001**
Patients with <20% 10-year risk, n (%)	349(87.3)	576(70.8)	925(76.3)	**<0.0001**
Patients with ≥20% 10-year risk, n (%)	51(12.8)	237(29.2)	288(23.7)	**<0.0001**
ASCVD(N = 1152)				
Mean score ±SD	9.07 ± 9.42	16.17 ± 12.35	13.96 ± 11.97	**<0.0001**
Patients with <20% 10-year risk, n (%)	314(78.5)	547(67.3)	861(71)	**<0.0001**
Patients with ≥20% 10-year risk, n (%)	46(11.5)	245(30.1)	291(24)	**<0.0001**

QRISK3 score- QRESEARCH version 3; GRACE- Global Registry of Acute Coronary Events; FRS-CHD- Framingham risk score; ASCVD- Atherosclerotic cardiovascular disease risk score, SERENE-CAG- Selecting Patients Of Rheumatic Heart Disease Undergoing Valve Surgery For Presurgical Coronary Angiography.

Table 3. Estimated cardiovascular risk according to low, intermediate and high risk categories.

Total Population	Low risk	Intermediate	High Risk	P value
QRISK3 (N = 1208)	399(33)	315(26.1)	494(40.9)	**<0.0001**
GRACE (N = 1208)	288(23.7)	479(39.5)	441(36.4)	**<0.0001**
FRS CHD(N = 1213)	549(45.3)	376(31)	288(23.7)	**<0.0001**
ASCVD(N = 1152)	566(46.7)	295(24.3)	291(24)	**<0.0001**

QRISK3 score- QRESEARCH version 3; GRACE- Global Registry of Acute Coronary Events; FRS-CHD- Framingham risk score; ASCVD- Atherosclerotic cardiovascular disease risk score, SERENE-CAG- Selecting Patients Of Rheumatic Heart Disease Undergoing Valve Surgery For Presurgical Coronary Angiography.

estimates, with QRISK3 categorizing a larger portion (40.9%) of the population as 'high risk' compared to FRS CHD (23.7%) and ASCVD (24%) mentioned in Table 3.

The number of vessels involvement increases in the high risk population as identified by these traditional risk scores (risk QRISK3 score 60.9%, risk GRACE score 54.9%, risk FRS-CHD score 34% and

Table 4. Risk QRISK3, ASCVD, AND FRS-CHD score according to number of vessels affected and LMCA disease.

Risk score	SVD N = 353(%)	DVD N = 225(%)	TVD N = 235(%)	LMCA N = 64(%)	P-value
QRISK3 <20%	212(60.1)	106(47.1)	92(39.1)	18(28.1)	**<0.0001**
>20%	141(39.9)	119(52.9)	143(60.9)	46(71.9)	
GRACE <20%	217(61.5)	111(49.3)	106(45.1)	29(45.3)	**0.003**
>20%	136(38.5)	114(50.7)	129(54.9)	35(54.7)	
ASCVD <20%	249(70.5)	163(72.4)	135(57.4)	29(45.3)	**0.002**
>20%	85(24.1)	61(27.1)	99(42.1)	35(54.7)	
FRS-CHD <20%	264(74.8)	157(69.8)	155(66)	40(62.5)	0.06
>20%	89(25.2)	68(30.2)	80(34)	24(37.5)	

QRISK3 score-QRESEARCH version 3; GRACE-Global Registry of Acute Coronary Events; FRS-CHD-Framingham risk score; ASCVD-Atherosclerotic cardiovascular disease risk score, SERENE-CAG-Selecting Patients Of Rheumatic Heart Disease Undergoing Valve Surgery For Presurgical Coronary Angiography; SVD-Single vessel disease; DVD-Double vessel disease, TVD-Triple vessel disease; LMCA-Left main coronary artery.

risk ASCVD score 42.1% consecutively). A total of 62 patients with left main coronary artery (LMCA) disease exhibited higher risk values, with QRISK3 showing the greatest efficiency in identifying high-risk scores and severe coronary artery disease (CAD) on subsequent coronary angiography ($P < 0.0001$) mentioned in Table 4.

ROC analysis was performed to determine a cut-off point for risk scores to predict coronary artery disease. The GRACE score showed an area under curve (AUC) of 0.78 (95% CI 0.76 to 0.807; $P < 0.0001$), with a new cut-off point of >112 providing 62.75% sensitivity and 71.94% specificity, for predicting CVD which was superior compared

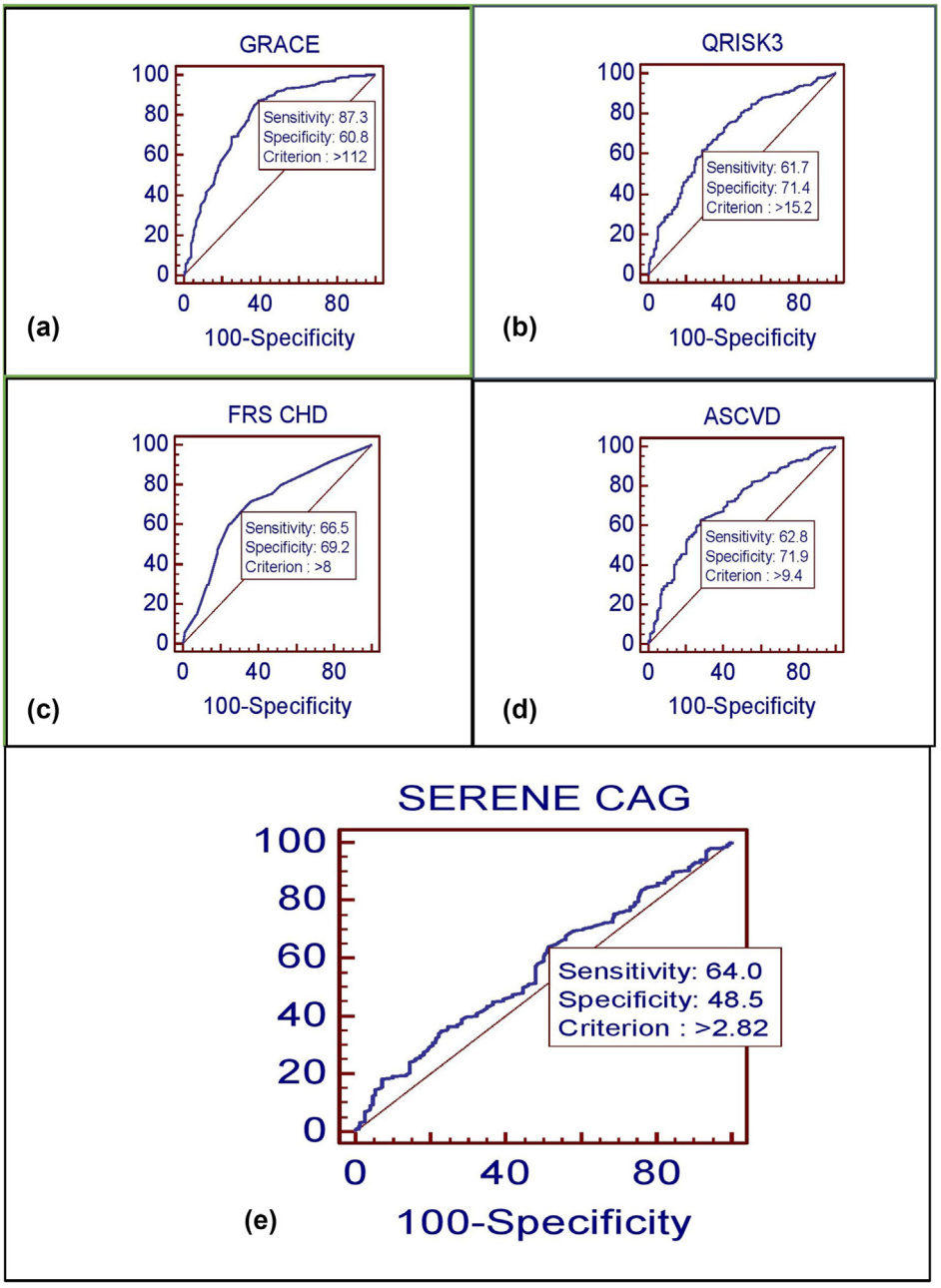

Fig. 1. (a) Receiver operator characteristics curve (ROC) analysis of risk GRACE score predicted CAD at the 87.3% sensitivity and 60.8% specificity at >112 cut off with 0.78 area under the curve (AUC). (b) Receiver operator characteristics curve analysis of risk QRISK3 score predicted CAD at the 61.7% sensitivity and 71.4% specificity at >15.2 cut off with 0.71 area under the curve (AUC). (c) Receiver operator characteristics curve analysis of risk FRS CHD score predicted CAD at the 66.5% sensitivity and 69.2% specificity at >8 cut off with 0.70 area under the curve (AUC). (d) Receiver operator characteristics curve analysis of risk ASCVD score predicted CAD at the 62.8% sensitivity and 71.9% specificity at >9.4 cut off with 0.70 area under the curve (AUC). (e) Receiver operator characteristics curve analysis of risk SERENE-CAG score predicted CAD at the 64% sensitivity and 48.5% specificity at >2.82 cut off with 0.57 area under the curve (AUC).

with other scores in our patients. This was an improvement on the previous cut-off of 140 for better predictability amongst previous studies (Fig. 1a). The QRISK3 score, with a cut-off of >15.2, showed an AUC of 0.71 (95% CI 0.679 to 0.731; P < 0.0001) which was higher than previous predefined cut off (≥10) value (Fig. 1b). These findings suggest need for re-establishing different "cut-offs" in Asian Indians as compared to Caucasian counterparts.

FRS-CHD risk score 0.70(95% CI 0.675 to 0.727; P < 0.0001) with >8 value gave 66.5% sensitivity and 69.2% specificity (Fig. 1c) while ASCVD risk score 0.70(95% CI 0.76 to 0.807; P < 0.0001) with >9.4 cut-off value gave 62.75% sensitivity and 71.94% specificity (Fig. 1d). For SERENE-CAG score 0.57 (95% CI 0.538 to 0.595; P 0.0001) gave >2.8 cut-off value with 63.96% sensitivity and 48.50% specificity similar to previous study (Fig. 1e).

Amongst these models, the risk GRACE score was superior in predicting CVD on coronary angiogram, but this model did not show 10-years risk burden in all comer population compared to those with CAD. However, when assessing the risk of CVD in obstructive CAD patients using QRISK3, FRS-CHD, ASCVD, and SERENE-CAG TRS, the comprehensive QRISK3 score model was found to be the most effective in clinical prediction of CVD.

4. Discussion

In this study we assessed CAD 10-years 'high risk' prediction using different TRS model. Our study recorded a higher prevalence of CAD in male patients (80%), increasing age (55.7 ± 10.8 years), Tobacco consumption (41.3%), type-II Diabetes (32%) as compared to obstructive CAD patients (P < 0.0001). Similar findings were reported in previously published Indian study conducted by Ramu et al. and Rahman ME et al. [10,11].

4.1. CV risk algorithms used for India

Several studies have also shown that the risk assessment systems which have been developed that are based on Western population, may actually underestimate the risk of CVD in Indians. Risk score FRS-CHD, ACC/AHA-ASCVD has low predictability of CVD in all-comers population. Manish Bansal et al. compared the 3 clinically most relevant and contemporary CV risk assessment models (risk FRS, ASCVD, JBS3 and WHO scores) in western Indian subjects [12].

Risk FRS score could identify lower proportion of patients with low risk (<20% 10 years) for prevalence of non-obstructive CAD patients. Hence, FRS is likely to underestimate CV risk in Indians, as has been demonstrated in some previous studies [12–14]. However, few previous studies also suggested risk FRS score was superior as CVD risk assessment model in Indian Population [15,16]. Contrary to this, in our study, FRS estimated only 29.2% of CAD patients as high risk as compared to QRISK3 and ASCVD risk score. In diabetic and male population, high risk patients were 27.9% and 30% respectively.

Another strategy that includes deploying numerous TRS in the same population group and to evaluate their accuracy in predicting CAD. The risk ACC/AHA score has been used to guide cholesterol management among adults instead of risk FRS score for all decision making regarding the use of statins in adults [6]. However, even in American populations, the accuracy of Risk ACC/AHA score has become a source of enormous conflict. In contrast, Duttagupta et al. , Durairaj G et al. and Sucharita reported ACC/AHA identified the higher number of people having high risk of developing CAD in their study [16,17]. Present study estimated only 30.1% of CAD patients as high risk as compared to QRISK3 and FRS-CHD risk score.

In our study, GRACE score was also evaluated to predict obstructive CAD with same variables used to risk stratify in our all-comer population. We propose a new cut-off (>112) of GRACE score; which is lower than previous studies. Higher GRACE score also predicted more extensive coronary artery involvement (multivessel disease) and it has been used for predicting in-hospital mortality in ACS patients [18,19].

The validity of the Risk GRACE score in predicting 10 years of 'high risk' cardiovascular disease (CVD) was not assessed in our study but only its association with obstructive CAD was assessed.

Risk QRISK3 score provided the highest risk (40.9%) estimates among all the risk assessment models compared. The QRISK3 score was most accurate in our study and is more likely to be applicable Asian Indian population. Large prospective cohort study was conducted by Aniruddh Patel et al. reported that QRISK3 estimates 1.4 fold higher 10-years' CV risk for individuals of South Asian and European ethnicity (13.7 and 9.6% respectively) [20].

Some other studies and reviews conducted on risk prediction algorithms for CVD in the Indian population have reported that the QRISK3 score was found to be more accurate across various study populations [7,20,21]. This score also performs better in diabetic patients to identify high risk patients. In diabetic patients, QRISK3 identifies the high-risk patient (40.9%), while FRS could identify least (27%).

ASCVD performed as intermediate (48%). Our study findings are supported for these findings by a few of the other studies as well [22,23].

SERENE CAG score was calculated from formula developed by K Sharma et al. SERENE- CAG was designed to evaluate obstructive CAD in patients of Valvular heart disease on pre-surgical coronary angiography and was not designed to estimate 10-year risk. Therefore, this score though is a good predictor of CAD in valvular heart disease planned for surgery, it may underestimate the risk of CVD in Indians at large [9].

We report QRISK3 score to be significantly predictive of CAD risk in general population as well as in obstructive CAD patients (49.6%) on coronary angiography ($P < 0.0001$) which was higher than other TRS. This score also identifies patients who are high risk and statin eligible accordingly as compared to other TRS. Therefore, this study suggests that FRS-CHD, ACC/AHA-ASCVD, GRACE and SERENE-CAG score may underestimate predicting high CV risk in our population. A substantial Indian population (27.4%) may not be identified using these TRS; thus warranting a need of indigenous, novel and more inclusive risk score for Indians with incorporation of lower cut-offs for these TRS.

4.2. Study limitations

Our study has a few limitations that should be noted. First, the cholesterol readings of some of our patients might have been lowered as they were on statins. It is anticipated that these changes led to an underestimation of CV risk in our study. However, it seems improbable that modifications in lipid profile would favourably impact one risk score over the other, given that it is incorporated in all four risk assessment models examined in this study. Hence, we believe these characteristics did not significantly alter our study findings as the main goal of the present investigation was to compare various risk assessment methods rather than to derive absolute risk estimates. Secondly, conducting a long-term prospective study is the only proper way to evaluate the predictive accuracy of various traditional risk scores.

5. Conclusion

QRISK3 score was more accurate for predicting obstructive CAD in Indian study population undergoing CAG as compared to other traditional risk scores viz. FRS-CHD, ACC/AHA-ASCVD. Large-scale prospective studies are needed to redefine Indian specific cut-offs and develop traditional risk scores for Asian Indian population.

Inform consent statement

Written informed consent was obtained from all patients and/or relatives enrolled into the study.

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Ethics information

The study protocol was approved by institutional ethics committee (UNMICRC/CARDIO/2018/14).

Author contributions

Conception and design of Study: SK, PJ. Literature review: SK, PJ, PK, PD, KM, DD. Acquisition of dataP: SK, PJ, PK, PD, KM, DD. Analysis and interpretation of data: SK, PJ, PK. Research investigation and analysis: SK, PJ, PK, PD, KM, DD. Data collection: SK, PJ, PK, PD, KM, DD. Drafting of manuscript: SK, PJ, PK, PD. Revising and editing the manuscript critically for important intellectual contents: SK, PJ, PK, PD. Data preparation and presentation: SK, PJ, PK, PD, KM, DD. Supervision of the research: PK, PD, KM, DD. Research coordination and management: SK, PJ, PK, PD, KM, DD.

Conflict of interest

None.

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