Original Article

Agreement between Thai Cardiovascular Risk Scores and Myocardial Perfusion Imaging: Exploring Associations and Clinical Implications

Kitwiwat Phuangmali, Chanan Sukprakun

Department of Radiology, Division of Nuclear Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

Abstract

Purpose: This study aimed to assess the agreement between the Thai cardiovascular (CV) risk score or pretest probability (PTP), and myocardial perfusion imaging (MPI), and to explore the association between abnormal MPI results and higher Thai CV risk scores or PTP risk. **Materials and Methods:** The study was conducted between March 2017 and December 2021, and included 128 patients. Myocardial perfusion gated single photon emission computed tomography imaging was performed on all patients, and agreement between the Thai CV risk score, PTP, and MPI was measured using weighted Cohen's kappa statistic. Logistic regression was used to calculate odds ratios (OR) and explore the association. **Results:** Fair agreement was observed between MPI and the Thai CV risk score (κ =0.269, P = 0.010), including patients with clinical chest pain (κ =0.367, P < 0.001). Subgroup analysis of patients with intermediate PTP revealed moderate agreement between MPI and the Thai CV risk score (κ =0.428, P = 0.002). Patients with intermediate (OR = 3.25, P = 0.010) or high (OR = 4.78, P = 0.001) Thai CV risk scores had significantly higher odds of having intermediate or high MPI results compared to those with low Thai CV risk scores. **Conclusion:** This study highlights the agreement between MPI and the Thai CV risk score and PTP. Higher Thai CV risk scores are associated with increased odds of abnormal MPI results. These findings provide valuable insights for clinical decision-making and patient management.

Keywords: *Association, cardiac event, health planning, logistic models, pretest probability*

Introduction

Cardiovascular diseases (CVD), particularly coronary artery disease (CAD), have become the leading cause of morbidity, mortality, and disability in developing countries. In Thailand, the proportion of deaths attributed to CVD is estimated to be around 23%.[1] Major risk factors for CAD include hypertension, dyslipidemia, smoking, diabetes, and overweight, with age and gender being nonmodifiable factors.[2] Several risk scores, such as the Framingham risk model, the World Health Organization/International Society of Hypertension risk prediction chart, and Thai CV risk score, are available for predicting the risk of CVD. However, it has been observed that the Framingham risk models may overestimate the risk of CVD in the Thai population due to differences in risk profiles and genetic factors.[3] Therefore, the Thai CV risk score, which is a locally developed tool that considers the unique characteristics of the Thai population, provides a more accurate assessment of CVD risk by utilizing data from a large general practice database and accounting for factors such as diabetes, which is common in Asian populations.[4]

Myocardial perfusion imaging (MPI) is a noninvasive alternative with high sensitivity (95%) and specificity (90%).[5] It can evaluate the presence of perfusion abnormalities and predict mortality from CVD with a high negative predictive value (98.8%).[6] While coronary angiography is considered the gold standard for evaluating CAD, it is an invasive procedure.[7] Therefore, MPI offers a valuable diagnostic tool for assessing CAD without the need for invasive interventions.

International guidelines emphasize the importance of pretest probability (PTP) in the investigation of stable CAD and provide recommendations for optimal investigation based on risk score categories.[7,8] However, to the best of our knowledge, there is no study to date that has investigated the agreement between PTP, the Thai CV risk score, and MPI in patients with or without

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Address for correspondence:
Dr. Chanan Sukprakun, Department of Radiology, Division of Nuclear Medicine, Faculty of Medicine, Chulalongkorn University, 1873 Rama IV Road, Pathumwan, Bangkok 10330, Thailand.
E-mail: chanan.s@chula.ac.th

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clinical chest pain. Therefore, the present study has two objectives: To determine the agreement between scoring methods, including the Thai CV risk score and PTP, and MPI, and to examine the association between abnormal MPI and patients with a higher the Thai CV risk score or higher PTP risk.

Materials and Methods

Subjects

This retrospective study utilized data retrieved from the Nuclear Medicine Division of the Radiology Department, covering from March 2017 to December 2021. Patients aged 35–70 years with various CV risk factors underwent stress MPI with Tc-99 m methoxyisobutylisonitrile using single photon emission computed tomography/computed tomography. Those who did not have lipid profile blood test results (cholesterol, low-density lipid, and high-density lipid) within 3 months before or after the MPI, as these results are necessary for calculating CV risk scores and those without records of hypertension or diabetes or with inadequate imaging protocols or poor image quality were excluded from the study. The study received ethical approval from the institutional review board.

Risk scores and myocardial perfusion imaging findings

Risk scores from MPI were classified into three groups, as determined by two physician's interpretations (a nuclear medicine physician and a nuclear medicine resident in training). Patients in the high-risk group had at least one of the following findings: A large stress-induced perfusion defect (>20% of left ventricular [LV] mass), multiple moderate-sized perfusion defects (≥2 territories, 10%–20% of LV mass), a fixed perfusion defect with LV dilation, a moderate stress-induced perfusion defect with LV dilation or increased lung uptake (lung heart ratio [LHR] >0.44), and a summed stress score (SSS) more than 13. Patients in the intermediate-risk group had at least one of the following findings: a moderate stress-induced perfusion defect (10%–20% of LV mass) without LV dilation or increased lung uptake (LHR >0.44), and a SSS of 9–13. Patients in the low-risk group had the following findings: normal or small myocardial perfusion defects (<10% of LV mass) at rest or with stress and an SSS <9.[7,9] In case of any disagreement, a consensus between the two readers will be reached.

The Thai CV risk scores, calculated based on the patient's age, gender, smoking, diabetes, systolic blood pressure, and lipid profile blood test results, were classified into three categories: low-risk (<10%), intermediate-risk (10%–20%), and high-risk (>20%). Similarly, the pretest probabilities, calculated based on the patient's age, gender, and chest pain characteristics (typical, atypical, or nonspecific chest pain), were also divided into three categories: Low-risk scores (<5%), intermediate-risk scores (5%–15%), and high-risk scores (>15%). The typical chest pain is defined as follows: (1) substernal chest pain or discomfort, (2) precipitated by exertion or emotional stress, and (3) relieved by rest and/or nitroglycerine. Atypical chest pain is defined as meeting two of the aforementioned criteria. If one or none of the criteria are present, symptoms are classified as nonspecific.

Statistical analysis

The agreement between the Thai CV risk scores, PTP, and MPI was measured using the weighted Cohen's kappa statistic. The agreement between the two physicians was calculated using the same statistic. Logistic regression was used to calculate the odds ratio (OR) to examine the association between abnormal MPI and patients with a higher Thai CV risk score or higher PTP risk. Results with a $P < 0.05$ were considered statistically significant. The data were analyzed using Stata (SE 17, StataCorp LLC, College Station, TX).

Results

This study included a total of 130 patients, with two patients being excluded due to poor imaging quality caused by movement. The final analysis consisted of data from 128 patients, including their characteristics [Table 1]. Regarding the risk assessments, the PTP classified 12 patients (9.4%) as low risk, 45 patients (35.2%) as intermediate risk, 33 patients (25.8%) as high risk, and 38 patients (29.7%) had no clinical chest pain. The proportions of patients in each category of Thai CV risk scores, MPI, and SSS are presented [Table 2].

Table 1: Demographic characteristics of the study population (*n*=128)

Characteristics	Mean±SD (range)/ number of patients (%)
Age (years)	61.4±7.6 (38.0–70.0)
BMI (kg/m^2)	26.0±4.7 (15.4–42.8)
Total cholesterol (mg/dL)	165.8±40.9 (77.0–343.0)
Low-density lipid (mg/dL)	94.5±32.7 (26.0–201.0)
High-density lipid (mg/dL)	46.3±13.3 (20.0–106.0)
Systolic blood pressure (mmHg)	132.4±17.7 (92.0–179.0)
Gender	
Male	70 (54.7)
Female	58 (45.3)
Diabetes	
Present	63 (49.2)
Absent	65 (50.8)
Hypertension	
Present	91 (71.1)
Absent	37 (28.9)
Smoking	
Present	15 (11.7)
Absent	113 (88.3)
Clinical chest pain	
Present	90 (70.3)
Absent	38 (29.7)

BMI: Body mass index, SD: Standard deviation

The results showed almost perfect agreement between the two physicians for MPI results (κ =0.809; $P < 0.001$). There was a fair agreement between MPI and the Thai CV risk (κ =0.269; $P = 0.010$). In patients with clinical chest pain, there was also fair agreement between MPI and the Thai CV risk (κ =0.367; $P < 0.001$). Subgroup analysis in patients with intermediate PTP showed moderate agreement between MPI and the Thai CV risk (κ =0.428; $P = 0.002$). There was a slight agreement between MPI and PTP (κ =0.167; $P = 0.025$) and moderate agreement between MPI and SSS (κ =0.514; $P < 0.001$) [Table 3].

Patients with intermediate or high Thai CV risk scores had significantly higher odds of having intermediate or high MPI results compared to those with low Thai CV risk. The OR for intermediate Thai CV risk score was 3.25 ($P = 0.010$), and the OR for high Thai CV risk score was 4.78 ($P = 0.001$). Patients with low, intermediate, or high PTP also had higher odds of having intermediate or high MPI results compared to those without clinical chest pain. However, there was no statistical significance [Table 4].

Table 2: Distribution of patients into low-, intermediate -, and high-risk categories based on Thai cardiovascular risk, pretest probability, myocardial perfusion imaging risk, and summed stress score

Risk scores	Low risk (%)	Intermediate risk (%)	High risk (%)
Thai CV risk (*n*=128)	53 (41.4)	39 (30.5)	36 (28.1)
PTP (*n*=90)	12 (13.3)	45 (50.0)	33 (36.7)
MPI risk (*n*=128)	76 (59.4)	13 (10.1)	39 (30.5)
SSS (*n*=128)	98 (76.6)	17 (13.3)	13 (10.1)
MPI risk (*n*=128)			
Thai CV risk (*n*=128)			
Low risk	41 (77.4)	2 (3.8)	10 (18.9)
Intermediate risk	20 (51.3)	5 (12.8)	14 (35.9)
High risk	15 (41.7)	6 (16.7)	15 (41.7)
PTP (*n*=90)			
Low risk	8 (66.7)	2 (16.7)	2 (16.7)
Intermediate risk	27 (60.0)	7 (15.6)	11 (24.4)
High risk	15 (55.6)	3 (13.3)	15 (31.1)
SSS (*n*=128)			
Low risk	72 (73.5)	11 (11.2)	15 (15.3)
Intermediate risk	4 (23.5)	2 (11.8)	11 (64.7)
High risk	0	0	13 (100.0)

PTP: Pretest probability, MPI: Myocardial perfusion imaging, SSS: Summed stress score, CV: Cardiovascular

Discussion

There was a high level of agreement between the two physicians for MPI results, indicating almost perfect agreement (κ =0.809; $P < 0.001$). This suggests consistent interpretation and reliability of MPI assessments between the two physicians. A moderate agreement was observed between MPI and SSS (κ =0.514; $P < 0.001$), indicating a notable level of concordance between the visual assessment of MPI results and the automated calculation of SSS.

Table 3: Agreement between myocardial perfusion imaging, Thai cardiovascular risk and pretest probability

Risk scores	Agreement	Weighted kappa; κ (95% CI)	*P*
MPI and Thai CV risk (*n*=128)	Fair	0.269 (0.189–0.309)	0.010
No chest pain (*n*=38)	Poor	−0.029 (−0.170–0.074)	0.572
Chest pain (*n*=90)	Fair	0.367 (0.299–0.555)	<0.001
Low PTP (*n*=12)	Fair	0.300 (0.000–0.447)	0.020
Intermediate PTP (*n*=45)	Moderate	0.428 (0.369–0.594)	0.002
High PTP (*n*=33)	Slight	0.111 (0.073–0.146)	0.202
MPI and PTP (*n*=90)	Slight	0.167 (0.043–0.290)	0.025
MPI and SSS risk (*n*=128)	Moderate	0.514 (0.405–0.666)	<0.001
Physician 1 and physician 2 (*n*=128)	Almost perfect	0.809 (0.807–0.847)	<0.001

CV: Cardiovascular, MPI: Myocardial perfusion imaging, PTP: Pretest probability, SSS: Summed stress score, CI: Confidence interval

Table 4: Association between the Thai cardiovascular risk or pretest probability and myocardial perfusion imaging

MPI (intermediate or high risk)	Unadjusted		Adjusted†	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Thai CV risk (*n*=128)				
Low versus intermediate risk	3.25 (1.32–7.97)	0.010*	3.31 (1.34–8.18)	0.010*
Low versus high risk	4.78 (1.90–12.04)	0.001*	4.49 (1.77–11.41)	0.002*
PTP (*n*=128)				
No chest pain versus low risk	1.08 (0.27–4.31)	0.910		
No chest pain versus intermediate risk	1.44 (0.58–3.58)	0.427		
No chest pain versus high risk	2.60 (0.99–6.85)	0.053		

†Adjusted for chest pain, *Statistical significance. CV: Cardiovascular, MPI: Myocardial perfusion imaging, CI: Confidence interval, OR: Odds ratio, PTP: Pretest probability

Previous research has demonstrated that expert visual assessment correlates more effectively with angiographic scores than automatic scoring methods. Therefore, incorporating SSS as an adjunct to visual assessment MPI is suggested.[10]

A fair agreement was observed between MPI and the Thai CV risk scores (κ =0.269; P = 0.010). This indicates some level of concordance between the risk scores and MPI findings. Similarly, in patients with clinical chest pain, there was also a fair agreement between MPI and the Thai CV risk scores (κ =0.367; P < 0.001). This suggests that the presence of chest pain may contribute to the association between the risk scores and MPI results. The subgroup analysis, which focused on patients with different PTP, only showed a moderate agreement between MPI and the Thai CV risk scores in the intermediate PTP group (κ =0.428; P = 0.002). This suggests that the level of agreement between these two parameters may vary depending on the PTP level. Due to a slight agreement between MPI and PTP (κ =0.167; P = 0.025), normal or low PTP does not exclude the possibility of high-risk MPI results.[11] Therefore, clinicians should consider additional assessments to accurately evaluate the risk of myocardial perfusion abnormalities, even in patients with normal or low PTP.

In terms of the association between risk scores and MPI results, patients with intermediate (OR = 3.25; P = 0.010) or high (OR = 4.78; P = 0.001) Thai CV risk scores had significantly higher odds of having intermediate or high MPI results compared to those with low Thai CV risk scores. These findings may indicate that higher risk scores are associated with a greater likelihood of abnormal MPI findings. In addition, patients with low, intermediate, or high PTP also had higher odds of having intermediate or high MPI results compared to those without clinical chest pain. However, the statistical significance of this association was not observed.

This study may have limited generalizability to populations with different cultural, ethnic, and socioeconomic backgrounds, and caution is advised when interpreting its findings due to the study sample being restricted to patients referred to a tertiary care center, which may not be representative of the general population.

Conclusion

The research findings highlight the agreement between MPI and various parameters such as the Thai CV risk scores, PTP, and SSS. The Thai CV risk score is an important tool for predicting adverse cardiac events in the general population, but it cannot replace MPI findings. The results also indicate the association between higher risk scores and increased odds of abnormal MPI results. These findings contribute to a better understanding of the relationship between different risk assessment tools and MPI outcomes, providing valuable insights for clinical decision-making and patient management.

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Conflicts of interest

There are no conflicts of interest.

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