

Association Of Myocardial Perfusion Scintigraphy Findings With Traditional Cardiovascular Risk Factors And HeartScore

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ABSTRACT

Cardiovascular diseases are the leading global cause of morbidity and mortality, primarily due to ischemic heart disease. This study aims to investigate the relationship between myocardial perfusion scintigraphy (MPS) findings and HeartScore values, and to evaluate its association with conventional cardiovascular risk factors. In our study, patients who were referred to the Department of Nuclear Medicine for MPS between April 1 and June 30, 2024, were included. Demographic and clinical data were collected from pre-scan anamnesis forms, including age, sex, diabetes mellitus (DM), hypercholesterolemia (HL), body mass index (BMI), coronary artery disease (CAD), smoking status, and family history. HeartScore values were calculated in a total of 144 patients, including 79 (all eligible for HeartScore calculation) with ischemia and 65 randomly selected controls without ischemia, to estimate the 10-year cardiovascular risk. A p-value of < 0.05 was considered statistically significant. Out of the 1,509 patients evaluated, MPS identified ischemia in 228 cases, infarction in 40, and normal perfusion in 1,241. A statistically significant increase in the incidence of ischemia was observed in parallel with rising HeartScore values ($p = 0.008$). MPS findings were significantly associated with the presence of CAD, HL and BMI ($p < 0.05$). However, no statistically significant association was found with DM. The significant association between MPS findings and estimated future cardiovascular risk supports the use of HeartScore as a valuable pre-screening tool. The presence of known risk factors, particularly CAD and HL, significantly increased the likelihood of ischemia on MPS, whereas BMI was inversely associated.

Key Words: Cardiovascular Disease. Myocardial Perfusion Scintigraphy. HeartScore.

Miyokard Perfüzyon Sintigrafisi Sonuçlarının Geleneksel Kardiyovasküler Risk Faktörleri ve HeartScore ile İlişkisi

ÖZET

Kardiyovasküler hastalıklar, dünyada morbidite ve mortalitenin en önde gelen nedenidir ve bu durum çoğunlukla iskemik kalp hastalığına bağlıdır. Bu çalışmanın amacı, miyokard perfüzyon sintigrafisi (MPS) bulguları ile HeartScore değerleri arasındaki ilişkiyi incelemek ve bu bulguların geleneksel kardiyovasküler risk faktörleri ile olan ilişkisini değerlendirmektir. Çalışmamıza, 1 Nisan – 30 Haziran 2024 tarihleri arasında Nükleer Tıp Kliniği'ne MPS için yönlendirilen hastalar dahil edilmiştir. Hastalara ait demografik ve klinik veriler, tetkik öncesi doldurulan anamnez formlarından elde edilmiş olup; yaş, cinsiyet, diyabetes mellitus (DM), hiperkolesterolemi (HL), vücut kitle indeksi (VKİ), koroner arter hastalığı (KVH), sigara kullanımı ve aile öyküsü gibi parametreleri içermektedir. HeartScore değerleri, 10 yıllık kardiyovasküler olay riskini tahmin etmek amacıyla, iskemi saptanan ve tamamı HeartScore hesaplamasına uygun olan 79 hasta ile iskemi tespit edilmeyen gruptan rastgele seçilen 65 kontrol hastası olmak üzere toplam 144 hastada hesaplanmıştır. $p < 0,05$ değeri istatistiksel olarak anlamlı kabul edilmiştir. Değerlendirilen toplam 1509 hastanın MPS sonuçlarına göre, 228 hastada iskemi, 40 hastada enfarktüs, 1241 hastada ise normal perfüzyon saptanmıştır. HeartScore değeri arttıkça MPS'de iskemi görülme sıklığı istatistiksel olarak anlamlı düzeyde artmıştır ($p=0,008$). MPS bulguları ile KVH, HL ve VKİ arasında anlamlı ilişkiler saptanmış ($p < 0,05$), ancak DM ile anlamlı bir ilişki bulunmamıştır. MPS bulguları ile gelecekteki kardiyovasküler olay riski arasındaki anlamlı ilişki, HeartScore'un klinik uygulamalarda değerli bir ön tarama aracı olarak kullanılabileceğini desteklemektedir. Özellikle KVH ve HL gibi bilinen risk faktörlerinin varlığı, MPS'de iskemi saptanma olasılığını anlamlı şekilde artırmış, buna karşılık VKİ ile iskemi arasında ters yönlü bir ilişki gözlenmiştir.

Anahtar Kelimeler: Kardiyovasküler Hastalık. Miyokard Perfüzyon Sintigrafisi. HeartScore.

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Cardiovascular disease (CVD) remains the leading global cause of morbidity and mortality. Among CVD-related deaths, ischemic heart disease is the most prevalent contributor, accounting for approximately 38% of deaths in women and 44% in men¹. Coronary artery disease develops through the complex interplay of multiple factors, which are broadly categorized as non-modifiable (age, sex, genetic predisposition, and family history) and modifiable (hypertension, smoking, obesity, dyslipidemia, and psychosocial stressors)². The cumulative impact of these risk factors significantly contributes to the global burden of CVD.

Myocardial perfusion scintigraphy (MPS) is a long-established, non-invasive imaging modality that continues to play a pivotal role in nuclear cardiology. By evaluating myocardial perfusion at the cellular level under stress and rest conditions, MPS provides essential insights into the diagnosis of CVD, assessment of therapeutic response, prognostic evaluation, and the detection of viable myocardial tissue³.

HeartScore is a web-based risk assessment tool that estimates the 10-year probability of a fatal cardiovascular event based on individual risk profiles, tailored to the epidemiological risk level of a given country⁴. Such tools are widely used in clinical practice and play a key role in cardiovascular risk management and the implementation of preventive strategies.

The primary objective of this study was to investigate the correlation between MPS findings and HeartScore values. The secondary objective was to assess the relationship between traditional cardiovascular risk factors—including diabetes mellitus (DM), hypercholesterolemia (HL), age, sex, obesity, smoking status, and a positive family history—and the presence or extent of ischemia as detected by MPS.

Material and Method

This retrospective study included patients who were referred to the Nuclear Medicine Department for MPS between April 1 and June 30, 2024, for the assessment of the presence and extent of reversible ischemia. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki and was approved by the Institutional Ethics Committee (approval date: 09.04.2024; protocol number: AEŞ-BADEK-2024-729). Owing to the retrospective design, informed consent was not required. Pre-scan anamnesis forms and electronic medical records were reviewed to obtain demographic and clinical data, including age, sex, DM, HL, obesity, smoking status, angina pectoris, and family history of CVD. Body mass index (BMI) classification was

defined as follows: lean/normal (BMI < 25 kg/m²), overweight (BMI 25–29.9 kg/m²), and obese (BMI ≥ 30 kg/m²).

Patients underwent either exercise or pharmacological stress testing (adenosine-based), selected according to individual clinical profiles. MPS imaging was performed using a SPECT/CT system (General Electric Medical Systems) following the intravenous administration of 18–30 mCi of technetium-99m methoxyisobutyl isonitrile (Tc-99m MIBI). Stress images were acquired 15–60 minutes post-injection, and rest images were obtained 30–60 minutes later. Attenuation correction was applied using low-dose CT. A two-day protocol was employed. Rest imaging was omitted in patients with normal stress imaging findings. In patients showing perfusion abnormalities on stress images, rest imaging was performed the following day.

Raw images were processed and scored based on the 17-segment model, with each segment assigned a score from 1 to 4 according to the degree of hypoperfusion observed between stress and rest phases. The ischemia rate was expressed as a percentage. Segments with <5% ischemia were considered normal. Segments with ≥5% ischemia were classified as ischemic. Infarcted segments, with or without associated ischemia, were classified as infarct group.

Exclusion criteria included patients under the age of 18, those who failed to reach 85% of their target heart rate during exercise testing, and those with incomplete medical records.

Ischemia and HeartScore Correlation Subgroup

HeartScore values were calculated using the web-based HeartScore calculator, in accordance with the European Society of Cardiology's SCORE2 and SCORE-OP risk models. Patients eligible for calculation were aged 40–89 years, without known CVD or DM, with non-HDL cholesterol levels between 115–266 mg/dL and systolic blood pressure between 100–200 mmHg. Parameters entered included age, sex, systolic blood pressure, total cholesterol, HDL and LDL cholesterol levels, and smoking status. Risk categorization was based on national risk classification; since Türkiye is considered a high-risk country, the corresponding calculator was used.

HeartScore values were calculated for 79 patients from the ischemic group who met eligibility criteria, and for 65 randomly selected non-ischemic patients. Risk categories were defined as follows: <7.5%, 7.5%–14.9%, and ≥15%.

Statistical Analysis

Data analysis was performed using SPSS version 25.0. Normality of distribution was assessed visually

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(histograms and probability plots) and analytically (Kolmogorov-Smirnov and Shapiro-Wilk tests). The association between MPS results and HeartScore was analyzed using the Kruskal-Wallis test. HeartScore comparisons between ischemic and non-ischemic groups were performed using the Mann-Whitney U test. Relationships between categorical variables were evaluated using the Chi-square test. Bonferroni correction was applied in pairwise subgroup analyses. A p-value < 0.05 was considered statistically significant.

Results

A total of 1,509 patients were included in the study. Of these, 841 were female (55.7%) and 668 were male (44.3%), with an age range of 22 to 89 years (median: 62 years). Myocardial perfusion scintigraphy (MPS) findings revealed ischemia (ischemia $\geq 5\%$) in 228 patients, infarction (infarction or infarction and ischemia) in 40 patients, and normal perfusion (no ischemia or <5% ischemia) in 1,241 patients.

The relationships between various clinical risk factors and MPS findings are presented in Table I. Significant associations were observed between MPS findings and a history of CVD, HL, and BMI. In contrast, no statistically significant association was found between DM and MPS results. However, HL showed a significant correlation with MPS findings ($p < 0.05$). The relationship between BMI groups and MPS results was further evaluated using post-hoc analysis. In pairwise comparisons among lean/normal weight, overweight, and obese individuals, a statistically significant difference was found between lean/normal and obese individuals regarding the rates of ischemia and infarction (Chi-square test, $p < 0.001$). According to these results, the frequency of ischemia and infarction was significantly higher among lean/normal individuals compared to obese individuals. The difference between lean/normal and overweight individuals was not statistically significant ($p = 0.083$), while the difference between overweight and obese groups approached significance ($p = 0.030$), but did not meet the Bonferroni-corrected threshold for statistical significance ($p < 0.0167$). Among individuals without CVD, a significant association was found between BMI and the presence of ischemia on MPS ($p < 0.01$), whereas this association was not statistically significant among those with established CVD ($p = 0.072$).

As HeartScore values increased, the rate of ischemia detected by MPS also increased. This difference was statistically significant based on the Chi-square test ($p = 0.008$) (Table II). The median HeartScore values in the ischemic and non-ischemic groups were calculated as 10.0 and 6.9, respectively. According to the Mann-

Whitney U test, this difference was statistically significant ($U = 1805.5$, $Z = -2.806$, $p = 0.005$) (Figure 2).

Table I. Distribution of Clinical Risk Factors Based on Myocardial Perfusion Scan (MPS) Results

MPS results		Normal	Ischemia	Infarction	Total	p değeri
DM	no	760(83.3%)	132(14.5%)	21(2.2%)	913	0.367
	yes	481(80.7%)	96(16.1%)	19(3.2%)	596	
HT	no	482 (83.2%)	83 (14.3%)	14 (2.4%)	579	0.712
	yes	759 (81.6%)	145 (15.6%)	26 (2.8%)	930	
CVD	no	933 (88.4%)	120 (11.4%)	3 (0.3%)	1056	<0.001
	yes	308 (68.0%)	108 (23.8%)	37 (8.2%)	453	
HL	no	717 (84.9%)	111 (13.1%)	17 (2%)	845	0.009
	yes	524 (78.9%)	117 (17.6%)	23 (3.5%)	664	
Family history of CVD	no	587 (81.3%)	110 (15.2%)	25 (3.5%)	722	0.165
	yes	654 (83.1%)	118 (15.0%)	15 (1.9%)	787	
Smoking	no	956 (83.3%)	166 (14.5%)	26 (2.3%)	1148	0.097
	yes	285 (78.9%)	62 (17.2%)	14 (3.9%)	361	
Angina pectoris	no	941 (83.2%)	164 (14.5%)	26 (2.3%)	1131	0.155
	yes	300 (79.4%)	64 (16.9%)	14 (3.7%)	378	
BMI	Underweight/normal	123 (71.9%)	38 (22.2%)	10 (5.8%)	171	<0.001
	Overweight	364 (79.5%)	78 (17.0%)	16 (3.5%)	458	
	Obese	754 (85.7%)	112 (12.7%)	14 (1.6%)	880	

*DM: Diabetes Mellitus, HT: Hypertension, CVD: Cardiovascular Disease, HL: Hyperlipidemia, BMI: Body Mass Index

Table II. Association Between MPS Results and HeartScore

		Normal	Ischemia	Total	p value
HeartScore(%)	<7.5	38 (56.7%)	29 (43.3%)	67	0.008
	7.5-14.9	18 (43.9%)	23 (56.1%)	41	
	≥ 15	9 (25.0%)	27 (75.0%)	36	

Figure 1: User interface of the HeartScore risk calculator

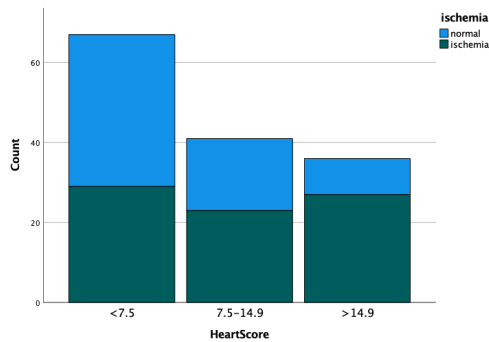


Figure 2:
Distribution of Ischemia Presence According to HeartScore Groups

Discussion and Conclusion

In this study, we evaluated the association between cardiovascular risk factors and MPS findings, and also analyzed the correlation between HeartScore and ischemia detected by MPS. No significant associations were found between MPS findings and DM, hypertension (HT), or smoking. In contrast, statistically significant associations were observed with HL, history of CVD, and BMI groups. The INTERHEART case-control study, which included 15,152 myocardial infarction (MI) cases and 14,820 age- and sex-matched controls across 52 countries, identified nine modifiable risk factors accounting for more than 90% of first MI events. Among these, HL stood out as the most prominent risk factor⁶.

While obesity increases the risk of developing CVD, overweight and obese individuals may experience better prognoses once the disease has developed—a phenomenon known as the “obesity paradox,” particularly observed in conditions such as heart failure, CVD, and atrial fibrillation⁷⁻⁸. In our study, a statistically significant association was found between BMI and the presence of ischemia on MPS in individuals without a diagnosis of CVD, whereas no such relationship was observed in those with established CVD. This finding does not directly support the classical definition of the obesity paradox; however, the absence of a statistically significant association in patients with CVD suggests that other contributing factors may play a role in this population.

HT plays an important role in the development of CVD and acute ischemic syndromes through various physical and neurohormonal mechanisms⁹. Despite its known impact, our study did not reveal a statistically significant association between HT and ischemia detected on MPS. This may be due to previously established HT diagnoses and the successful medical management of blood pressure in the study population.

The relationship between smoking and ischemia remains complex. In a 2021 study by Salehi et al., which analyzed 11 studies involving 6,037 participants, mixed findings were reported regarding the severity and extent of coronary artery disease. While six studies found no significant association between smoking and the number of affected arteries, five studies identified a relationship between smoking and disease severity¹⁰. In our study, no significant association was found between smoking status and ischemia detected on MPS. However, smoking was recorded only as a binary variable (smoker/non-smoker), and the degree of exposure (e.g., pack-years) was not assessed. This limitation may have hindered the ability to fully capture the impact of smoking on ischemia.

DM is considered a high-risk factor equivalent to established CVD in SCORE calculations⁴. Therefore, DM was not included in the HeartScore analysis in our study. Interestingly, no statistically significant association was found between DM and MPS findings. While unexpected, this could be explained by adequate metabolic control among diabetic patients or a low prevalence of silent ischemia within this subgroup.

Another important finding of our study is the increase in ischemia detection on MPS with higher HeartScore values. The results of HeartScore analyses revealed a significant association between predicted cardiovascular event risk and MPS findings. Both categorical and median analyses demonstrated that higher HeartScore values were associated with increased rates of ischemia. The significant difference in HeartScore medians between the ischemic and non-ischemic groups suggests that risk estimation tools may have the potential to reflect non-invasive imaging findings. This finding implies that HeartScore may aid in predicting the necessity of MPS in clinical decision-making processes.

Since both nuclear tracers and the CT component contribute to total ionizing radiation exposure in SPECT/CT systems, appropriate patient selection is essential—not only to improve diagnostic efficiency, but also to reduce unnecessary radiation exposure¹¹. Especially through pretest probability assessment, selecting appropriate patients is critical to ensure patient safety and to reduce diagnostic workload and costs.

In this study, we hypothesized that the HeartScore system—recommended by the European Society of Cardiology and easily applicable in clinical settings—could serve as a useful tool for the preliminary assessment of cardiovascular risk levels.

One of the main strengths of this study is the large sample size and the use of a quantitative method for detecting ischemia on MPS. However, its retrospective design and the inclusion of HeartScore

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analysis in only a specific subgroup of eligible patients are among the study's limitations.

In conclusion, HL and a history of CVD were strongly associated with the presence of ischemia on MPS. HeartScore demonstrated a significant correlation with both future cardiovascular risk and MPS findings, suggesting its potential value as a pre-screening tool in clinical practice.

Researcher Contribution Statement:

Idea and design: S.D.S, D.C, A.C, A.D, S.G.A

Data collection and processing: S.D.S, A.D., A.C, D.C, S.G.A

Analysis and interpretation of data: S.D.S, S.G.A, A.C, A.D, D.C

Writing of significant parts of the article: S.D.S, A.C, S.G.A, D.C, A.D

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References

1. Byrne RA, Rossello X, Coughlan JJ, et al. ESC Scientific Document Group. 2023 ESC Guidelines for the management of acute coronary syndromes. *Eur Heart J*. 2023;44(38):3720-3826.
2. Shahjehan RD, Sharma S, Bhutta BS. Coronary Artery Disease. [Updated 2024 Oct 9]. In: StatPearls [Internet]. StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/sites/books/NBK564304/?utm_source=chatgpt.com
3. Semirgin SU, Algül Gİ, Tosun FC. Myocardial Perfusion Imaging: Pitfalls and Artifacts. *Nucl Med Semin*. 2024;10(1):62-80.
4. European Society of Cardiology. *HeartScore*. Accessed 24 May 2025. https://www.heartscore.org/en_GB/
5. Canbaz Tosun F, Özdemir S, Şen F, et al. Miyokardiyal Perfüzyon SPECT Uygulama Kılavuzu. *Nucl Med Semin*. 2020;6(2):90-134. doi:10.4274/nts.galenos.2020.0010.
6. Joseph, P, Leong, D, McKee, M, et al. Reducing the global burden of cardiovascular disease, Part 1: The epidemiology and risk factors. *Circulation Research*. 2017;121(6):677-694.
7. Tutor AW, Lavie CJ, Kachur S, Milani RV, Ventura HO. Updates on obesity and the obesity paradox in cardiovascular diseases. *Prog Cardiovasc Dis*. 2023;78:2-10.
8. Lavie CJ, Milani RV, Ventura HO. **Obesity and cardiovascular disease: risk factor, paradox, and impact of weight loss.** *J Am Coll Cardiol*. 2009;53(21):1925-1932.
9. Volpe M, Gallo G. Hypertension, coronary artery disease and myocardial ischemic syndromes. *Vascular Pharmacology* 2023;153:107230.
10. Salehi N, Janjani P, Tadbiri H, Rozbahani M, Jalilian M. Effect of cigarette smoking on coronary arteries and pattern and severity of coronary artery disease: a review. *J Int Med Res*. 2021;49(12):3000605211059893.
11. Caobelli F, Dweck MR, Albano D, et al. Hybrid cardiovascular imaging. A clinical consensus statement of the european association of nuclear medicine (EANM) and the european association of cardiovascular imaging (EACVI) of the ESC. *Eur J Nucl Med Mol Imaging*. 2025;52(3):1095-1118.

