Monika Štalc[1]

Thoracic Aorta and Coronary Artery Calcification in Patients Referred to Myocardial Perfusion Scintigraphy

ABSTRACT

KEY WORDS: myocardial perfusion scintigraphy, coronary calcification, thoracic aorta calcification, CT

BACKGROUNDS. Myocardial perfusion imaging (MPI) is a well-established non-invasive imaging technique for the diagnosis of coronary artery disease (CAD). MPI may detect obstructive CAD but fail to discover subclinical atherosclerosis. With advances in technology, low-dose CT for attenuation correction has become an important part of nuclear cardiology. CT in MPI allows for the visualization of thoracic aorta calcification (TAC) and coronary artery calcification (CAC). The aim of the study was to evaluate the prevalence of TAC and CAC in patients referred to MPI. METHODS. Clinical characteristics, MPI results, and prevalence of CAC and TAC were collected from 90 consecutive patients with an intermediate likelihood of CAD and without previously known atherosclerosis who were admitted to MPI. RESULTS. Out of 90 patients, 32 (35.6%) had ischemia, and 58 (64.4%) patients had normal MPI. Calcification was present in 63.3% of all patients on low-dose CT (75.0% with ischemia versus 57.0% with normal MPI, $p = 0.09$). Most patients with CAC had concomitant TAC. In more than a quarter of patients, only TAC was present. More patients with ischemic MPI had CAC compared to patients with normal MPI (53.1% versus 25.8%, $p = 0.01$). Patients with normal MPI and TAC or CAC were older (71.1 ± 7.6 years versus 56.5 ± 9.2 years, $p < 0.001$) and had more arterial hypertension (78.9% versus 52.0%, $p = 0.03$) than patients without calcification. Patients with normal MPI and suffering only from TAC had more arterial hypertension than patients with CAC (94.4% versus 60.0%, $p = 0.01$). CONCLUSIONS. The combination of myocardial perfusion, CAC, and TAC from a single MPI scan may have a complementary role in the management of patients with an intermediate risk of CAD. In addition to improving risk estimation, reporting visually estimated calcification may influence patient management decisions.

[1] Doc. dr. Monika Štalc, dr. med., Klinika za nuklearno medicino, Univerzitetni klinični center Ljubljana, Zaloška cesta 7, 1000 Ljubljana; Katedra za inteno medicino, Medicinska fakulteta, Univerza v Ljubljani,, Zaloška cesta 7, 1000 Ljubljana; monika.stalc@gmail.com

INTRODUCTION

Myocardial perfusion imaging (MPI) is a well-established non-invasive imaging technique for the diagnosis and prognosis of coronary artery disease (CAD) in patients with an intermediate pretest probability for CAD *(1)*. A functional assessment of CAD through the evaluation of stress-induced ischemia is provided by MPI. Detecting obstructive CAD may be possible with MPI, but it may fail to discover subclinical atherosclerosis.

Coronary artery calcification (CAC) and thoracic aorta calcification (TAC) are frequent incidental findings on non-gated thoracic CT. With advances in technology, low-dose CT has become an important part of nuclear cardiology. Gamma cameras have a built-in CT scanner, which is routinely used for attenuation correction. The visualization of TAC and CAC is possible with CT in MPI. When paired with nuclear medicine imaging, these two modalities can provide complementary diagnostic information. Until recently, calcination was not routinely evaluated or reported in MPI *(2)*.

The quantitative Agatston score is a well-established prognostic marker for CAD. A dedicated non-contrast ECG-gated cardiac CT is used to formally evaluate CAC. However, CAC can be identified on non-gated thoracic CT with excellent diagnostic accuracy compared to gated CT. For non-gated thoracic CT in routine clinical practice, a simple visual quantification is recommended. The low-dose CT visual calcium score correlated well with the Agatston score. Visually estimated CAC on chest CT in patients without known CAD is associated with an increased rate of major adverse cardiovascular events. An increased rate of myocardial infarction and a need for revascularization interventions were found to be associated with CAC on routine chest CT. The visually estimated coronary calcium score has also been shown to improve MPI risk stratification in clinical practice *(2, 3)*.

A wealth of data has also emerged regarding TAC and risk stratification, principally from additional analyses of primary prevention cohorts that focused on CAC. Systemic atherosclerosis is reflected by TAC, and its severity may be associated with the severity of CAD. All-cause mortality has been related to TAC, independently of conventional risk factors and the presence of CAC. A few studies reported no significant correlation between TAC and cardiac events. Despite the limited prognostic role of TAC beyond CAC, the reporting of TAC on all non-contrast chest CT and calcium scoring scans even without CAC is recommended *(4–6)*.

Since a CT for attenuation correction is embedded within the MPI workflow with no additional cost or radiation, it is beneficial to extract anatomical information from the exam. The aim of our study was to evaluate the prevalence of TAC and CAC in patients referred to MPI.

PATIENTS AND METHODS

This was a retrospective study with a population taken from a single tertiary medical centre. Data was analysed from 90 consecutive patients with an intermediate likelihood of CAD and without previously known atherosclerosis who were referred for MPI. The clinical characteristics of the patients were prospectively collected at the time of the MPI study. All patients were assigned to a two-day stress/rest protocol. They underwent either bicycle exercise stress (ERG 911 S plus, Schiller™) or vasodilator stress (regadenoson 400 µg or dipyridamole 0.56 mg/kg). An hour after the intravenous injection of Technetium-99m tetrofosmin 450 MBq (Myoview™, GE Healthcare), we imaged the patients on a Symbia Intevo® gamma camera with a two-slice CT. The CT parameters for the attenuation correction included a tube current of 30 mAs, a voltage of 130 kVp, a pitch of 1.5 and a B08s kernel for reconstruction. We performed stress protocols, image acquisition, and recon-

struction according to the guidelines of the European Association of Nuclear Medicine (EANM). Two experienced nuclear cardiologists interpreted the stress MPI. The presence of CAC and TAC was detected visually on dedicated commercial software using a soft-tissue window, and expressed binary (present or absent). The reader was blinded to the MPI results.

Statistical methods

The Kolmogorov-Smirnov test was used to assess normal distribution in all cases. Continuous variables are presented as mean ± standard deviation and were compared using Student's t-test. Categorical variables are reported as frequencies with percentages and were compared using the x^2 test. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

The clinical characteristics and calcification data of the patient population stratified by MPI result are shown in table 1. Out of 90 patients, 32 (35.6%) had ischemia and 58 (64.4%) had normal MPI. More patients with ischemia had diabetes; there were no differences in other cardiovascular risk factors between the groups. Patients with ischemic MPI had more CAC compared to patients with normal MPI. Most patients with CAC had concomitant TAC. In more than a quarter of patients, only TAC was present. Calcification was present in 57.0% of patients with normal MPI. A representative case with no evidence of ischemia on MPI but CAC and TAC on CT is shown in figure 1. Patients with normal MPI and calcification were older (71.1 ± 7.6 versus 56.5 ± 9.2, p < 0.001) and had more arterial hypertension (26 (78.9%) versus 13 (52.0%), p = 0.03) than patients without calcification. Patients with normal MPI and suffering only from TAC (N = 18) had more arterial hypertension than patients with CAC (N = 15) (17 (94.4%) vs. 9 (60.0%), p = 0.01).

Table 1. Clinical characteristics and calcification data in patient population. N – number, MPI – myocardial perfusion imaging, SD – standard deviation, CAC – coronary artery calcification, TAC – thoracic aorta calcification.

	All (N = 90)	Ischemia on MPI (N = 32)	Normal MPI (N = 58)	P-value
Age (mean ± SD) (years)	65.7 ± 10.6	67.3 ± 9.5	64.8 ± 11.1	0.28
Female gender	51 (56.6%)	15 (46.8%)	36 (62.0%)	0.16
Arterial hypertension	64 (71.1%)	25 (78.1%)	39 (67.2%)	0.88
Diabetes mellitus	23 (25.5%)	12 (37.5%)	11 (18.9%)	0.05
Hyperlipidemia	42 (46.7%)	18 (56.2%)	24 (41.4%)	0.17
Smoking	13 (14.4%)	5 (15.6%)	8 (13.8%)	0.81
All calcification	57 (63.3%)	24 (75.0%)	33 (56.9%)	0.09
CAC	32 (35.5%)	17 (53.1%)	15 (25.8%)	0.01
TAC	53 (58.9%)	23 (71.8%)	30 (51.7%)	0.06
Only CAC	4 (4.5%)	1 (3.1%)	3 (5.1%)	0.65
CAC and TAC	28 (31.1%)	16 (50.0%)	12 (20.7%)	0.004
Only TAC	25 (27.8%)	7 (21.9%)	18 (31.0%)	0.35

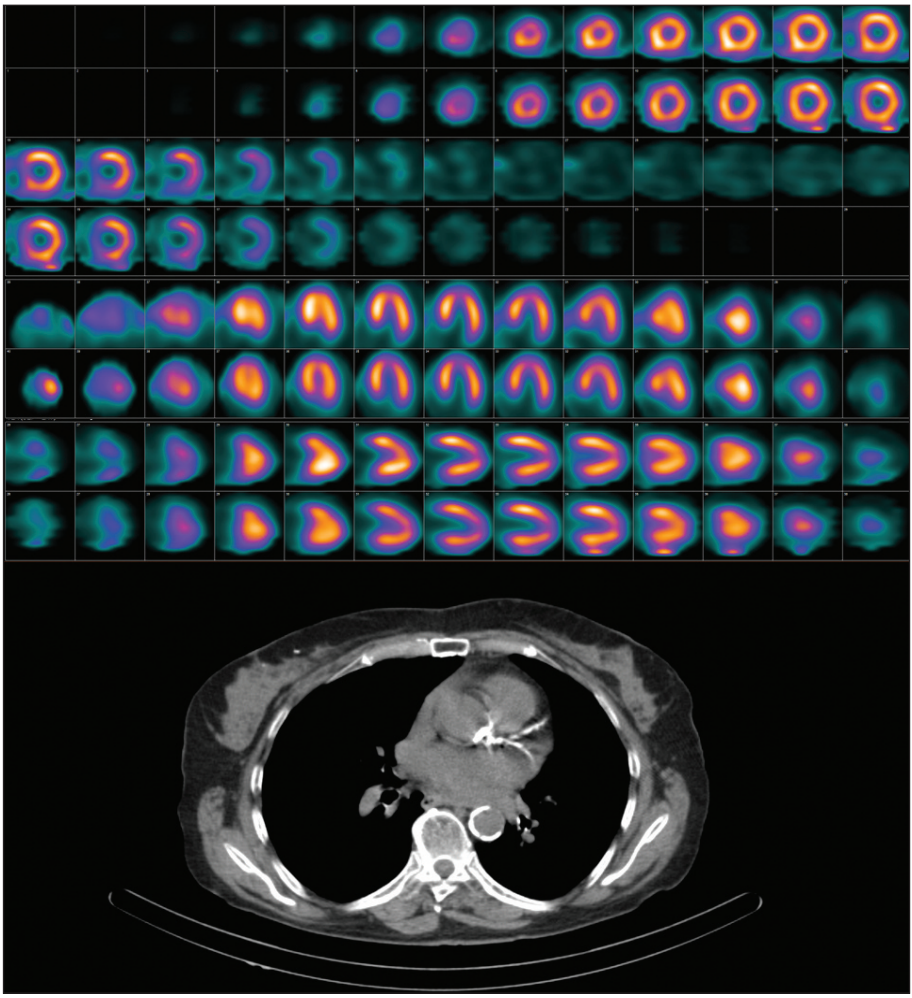

Figure 1. Coronary and thoracic aorta calcification were noted in a 73-year-old female patient with no evidence of ischemia on the stress myocardial perfusion scintigraphy.

DISCUSSION

The present study demonstrated that almost two-thirds of the patients without previously known atherosclerosis referred for MPI had TAC or CAC. Most patients with CAC had concomitant TAC; in more than a quarter of patients, only TAC was present. Our study also showed a high prevalence of subclinical atherosclerosis in patients with normal MPI.

Patients with ischemic MPI had more CAC compared to patients with normal MPI. However, 26.0% of patients with normal MPI had CAC. Coronary atherosclerosis is indicated by CAC, however, it does not necessarily imply obstructive CAD. In contrast, ischemia is the consequence of a flow-limiting lesion or a microvascular dysfunction. The integration of CAC in MPI results may provide an opportunity for intensive risk factor modification, including the treatment of hyperlipidemia *(2)*.

In a recent study, 69% of patients with a normal MPI had an Agatston score > 0 *(2)*.

The percentage of our patients with normal MPI and CAC was significantly lower. The main reason for the difference is that the visually estimated CAC on a CT for attenuation correction may underestimate the extent of CAC due to cardiac motion artifacts, slice thickness, and low image resolution.

Almost one third (31.0%) of our patients with normal MPI had only TAC. Published data on TAC on a low-dose CT in MPI is scarce. In a previous study, TAC on echocardiography was associated with abnormal myocardial perfusion *(5)*. In contemporary practice, the value of any imaging test is framed within a hierarchical context, beginning with technical considerations, diagnostic accuracy and culminating with changes in therapy and improved outcomes. This high standard has not yet been met by TAC. Although TAC may identify a patient at higher risk for noncoronary events, the extent of reclassification and implications for management remain unclear. One of the reasons for the inconclusive results from the studies regarding TAC and risk stratification are different fields of view used on a CT. The most important distinction is whether the aortic arch and proximal descending aorta have been included, since 60% of all TAC are found in this area *(5)*. In our patients, all parts of the thoracic aorta were visualized.

Only 43.0% of patients with normal MPI have no calcification. They were younger and had less arterial hypertension than patients with calcification. A strong association between the presence of CAC and advancing age in patients with normal MPI was already shown in a previous study. They also found no association between CAC and arterial hypertension *(7)*.

Limitations

There are several limitations to our study. The study was conducted as a retrospective single tertiary centre study, and we do not have a correlation between our results and invasive or CT coronary angiography. The studied patient population was too small to draw definite conclusions. Due to the lack of standardization, we chose a binary approach for CAC and TAC reporting. For patient risk stratification, calcification can be categorized as mild, moderate, or severe. With low-dose CT, only TAC is detected; in the thoracic aorta, the noncalcified atheroma may be especially prominent, and calcification may not completely encompass cardiovascular risk related to thoracic aorta atherosclerosis.

CONCLUSIONS

The combination of myocardial perfusion, CAC, as well as TAC from a single MPI scan may have a complementary role in the management of patients with an intermediate risk of CAD. In addition to improving risk estimation, reporting visually estimated calcification may influence patient management decisions. Further prospective, large-scale studies are needed to investigate the presence of subclinical atherosclerosis (CAC and TAC) in patients referred to MPI for better risk stratification.

REFERENCES

1. Knuuti J, Wijns W, Saraste A, et al. 2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes. Eur Heart J. 2020; 41 (3): 407–77. doi: 10.1093/eurheartj/ehz425
2. Al-Mallah MH, Bateman TM, Branch KR, et al. 2022 ASNC/AAPM/SCCT/SNMMI guideline for the use of CT in hybrid nuclear/CT cardiac imaging. J Nucl Cardiol. 2022; 29 (6): 3491–535. doi: 10.1007/s12350-022-03089-z
3. Trpkov C, Savtchenko A, Liang Z, et al. Visually estimated coronary artery calcium score improves SPECT-MPI risk stratification. Int J Cardiol Heart Vasc. 2021: 35: 100827. doi: 10.1016/j.ijcha.2021.100827
4. Canan A, Ghandour AA, Saboo SS, et al. Opportunistic screening at chest computed tomography: Literature review of cardiovascular significance of incidental findings. Cardiovasc Diagn Ther. 2023; 13 (4): 743–61. doi: 10.21037/cdt-23-79
5. Desai MY, Cremer PC, Schoenhagen P. Thoracic aortic calcification: Diagnostic, prognostic, and management considerations. JACC Cardiovasc Imaging. 2018; 11 (7): 1012–26. doi: 10.1016/j.jcmg.2018.03.023
6. Williams MC, Abbas A, Tirr E, et al. Reporting incidental coronary, aortic valve and cardiac calcification on non-gated thoracic computed tomography, a consensus statement from the BSCI/BSCCT and BSTI. Br J Radiol. 2021; 94 (1117): 20200894. doi: 10.1259/bjr.20200894
7. Fathala AL, Bukhari SQ, Shoukri M, et al. High prevalence of coronary artery calcification in Saudi patients with normal myocardial perfusion. Ann Saudi Med. 2017; 37 (2): 154–60. doi: 10.5144/0256-4947.2017.154