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ORIGINAL PAPER

Echocardiographic calcification score in patients with low/intermediate cardiovascular risk

Kristof Hirschberg[1] · Manuel Reinhart[1] · Derliz Mereles[1] · Lorenz Uhlmann[2] · Florian André[1] · Johannes Riffel[1] · Marco Ochs[1] · Hugo A. Katus[1]

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Abstract

Purpose Calcification of aortic valve and mitral annulus is associated with cardiovascular risk factors, morbidity and mortality. Assessment of cardiac calcification with echocardiography is feasible, however, only few structured scoring systems have been established so far with limited prognostic data. This study aimed to evaluate an echocardiographic calcification score (echo-CCS) in patients with low/intermediate cardiovascular risk.

Methods Digitally stored echocardiography studies of 151 patients (median age 64, 49.7% male) from February 2008 to December 2009 were retrospectively reviewed for calcifications of the aortic valve, aortic root, mitral annulus, papillary muscles and ventricular septum. A calcification score ranging from 0 to 5 was assigned to every patient and its relation to computed tomography calcium score, coronary stenosis and ESC SCORE was assessed. Follow-up data were collected from 149 patients (98.7%) with a median of 6.2 years. Logistic regression and Kaplan–Meier analysis were performed to assess the association of the echo-CCS with significant coronary artery disease (≥ 50% stenosis) and risk for cardiac events and all-cause mortality.

Results An association of the echo-CCS with the ESC SCORE ($\rho = 0.5$; $p < 0.001$) and a good correlation of the echo-CCS with the Agatston score ($\rho = 0.73$; $p < 0.001$) can be observed. Univariate regressions revealed that echo-CCS is a significant predictor for cardiac events [OR = 5.1 (CI: 1.7–15.0); $p = 0.003$], coronary intervention [OR = 2.8 (CI: 1.3–5.7); $p = 0.006$], hospitalisation for cardiac symptoms [OR = 2.0 (CI: 1.2–3.4); $p = 0.007$], all-cause mortality [OR = 2.6 (CI: 1.3–5.5); $p = 0.01$] and significant CAD [OR = 3.2 (CI: 1.9–5.4); $p < 0.001$].

Conclusions We demonstrated the prevalence of an easily obtainable, radiation-free calcification score in patients with low/intermediate cardiovascular risk. The strong association with CT-calcium scoring may evoke its potential as an alternative method in CV risk assessment.

Keywords Echocardiography · Computed tomography · Calcification · Score · Coronary artery disease

Introduction

Cardiovascular diseases (CVD) are still a major cause for disabilities and deaths in developed countries [1, 2]. Coronary artery disease (CAD) can be symptomless for a long time [3], until the first, frequently fatal cardiac event occurs [4]. The Systematic Coronary Risk Evaluation (SCORE) is a risk stratification score developed by the European Society of Cardiology (ESC) to identify individuals at high CVD-risk and to estimate the risk of a fatal cardiac event in the next 10 years [5]. However, the ESC Task Force and further studies [5, 6] formulated that the SCORE could still be optimized by additional parameters to refine risk stratification. Several noninvasive tests and imaging methods are in focus

Kristof Hirschberg and Manuel Reinhart contributed equally to this work.

✉ Kristof Hirschberg
Kristof.Hirschberg@med.uni-heidelberg.de

1 Department of Internal Medicine III, Cardiology, Angiology and Pneumology, University of Heidelberg, Im Neuenheimer Feld 410, 69120 Heidelberg, Germany

2 Institute of Medical Biometry and Informatics, University of Heidelberg, Heidelberg, Germany

of interest regarding this issue [7–9]. One potential parameter could be the computed tomography (CT) calcium scoring with the potential for detection of subclinical CAD and prediction of future cardiovascular events [5, 10–13]. However, ionizing radiation limits its use, even if radiation dose could be significantly reduced over the last years [14, 15].

Numerous studies showed that the assessment of calcified cardiac structures during standard echocardiography could be a radiation-free and easily obtainable alternative to the CT-calcium scoring. Echocardiographically assessed calcifications have already proven their predictive value for coronary artery disease [16–21] and their prognostic value for future cardiovascular (CV) events [22–25]. Our previously published novel echocardiographic calcification score (echo-CCS) [26], which includes more cardiac calcifications than former scores, demonstrated its value as independent predictor for significant CAD and for increased all-cause mortality in patients with high CV risk. The aim of the present study was to analyze the diagnostic and prognostic value of the echo-CCS in a low/intermediate risk population by demonstrating its correlation with the conventional Agatston score, the ESC SCORE and future cardiovascular events.

Methods

Study population

The study was designed as a single-center retrospective study at our Department in a low/intermediate CVD-risk population. The population comprised 151 patients (from February 2008 to December 2009), all of whom received a standard transthoracic echocardiographic examination as well as a cardiac computed tomography (calcium scoring and coronary CT-angiography). The median time between both examinations was 17 days (IQR: 9–30 days). Patient's baseline data and cardiovascular risk factors were collected retrospectively from our patient information system i.s.h.med® (Cerner, SAP, Walldorf, Germany). Age, diabetes, hypercholesterolemia, hypertension, obesity and smoking were considered as cardiovascular risk-factors. Furthermore, relevant co-morbidities such as renal failure were assessed [27, 28]. For estimating the CVD-risk of this population, the ESC SCORE for every patient was calculated [5]. Patients with a SCORE $\geq$ 5% were considered to be at high risk for CVD. In addition, the CVD-risk was assessed via Agatston score. According to the ESC guidelines from 2016, an Agatston score $\geq$ 300 was considered as an indicator for a high cardiovascular risk, while an Agatston score < 300 was classified as low cardiovascular risk [5]. All patients had appropriate clinical indications for comprehensive echocardiography and cardiac CT. The study was in agreement with the Declaration of Helsinki.

Echocardiographic calcification score (echo-CCS) assessment

For the evaluation of the echo-CCS we reviewed standard comprehensive transthoracic echocardiographic studies, which were digitally stored on PACS (Picture Archiving and Communication System) and offline available on workstations (Centricity, GE Healthcare Vingmed, Trondheim, Norway). The examinations were analyzed by an expert reader blinded to all clinical data. Echocardiographic examinations were performed on commercially available ultrasound systems (Vivid 7, GE Healthcare Vingmed, Trondheim, Norway; ie33, Philips, Eindhoven, The Netherlands and SSD-5500 PureHD, Hitachi Aloka Medical, Tokyo, Japan) according to the guidelines of the American Society of Echocardiography [29]. The comprehensive examination included standard 2D echocardiography for anatomic imaging and Doppler echocardiography for assessment of velocities. All examinations included a view from the parasternal short and long axis as well as the apical two, three, four and five chamber views using 1.5-4.0 MHz phased-array transducers.

The echo-CCS [26] assessed calcifications at the following anatomical structures of the heart: aortic root, aortic valve, mitral annulus, papillary muscle and ventricular septum. A calcification was defined as presence of a bright echocardiographic density as compared to adjacent areas of the same structure. Each of the five structures was categorized either as presence of calcification (1 point) or absence of calcification (0 points). Consequently, a score between 0 points (minimum) and 5 points (maximum) was attainable by summation of all calcified structures.

Cardiac computed tomography (CT)

All 151 patients underwent a cardiac CT examination due to suspected CAD including calcium scoring and coronary CT-angiography (CTA). CT examinations were performed on a 256-slice CT (Brilliance iCT, Philips Healthcare, Cleveland, OH, USA). Prior to data acquisition, metoprolol was incrementally administered intravenously to attain a heart rate $\leq$ 65/min. Furthermore, glycerol trinitrate was given sublingually immediately before the scan. Coronary calcium scan was conducted with a tube potential of 120 kV and a tube current of 364 mA applying a prospectively ECG-triggered axial acquisition mode. The Agatston score was measured on a dedicated workstation [10]. Coronary CTA performed applying a prospectively ECG-triggered axial acquisition mode in patients with a regular heart rate < 65/min and otherwise employing a retrospectively ECG-gated helical scan mode. The detector configuration was 2 × 96/11/128 × 0.625 mm with z-flying focal spot and gantry rotation time was 270 ms. Tube potential was 120 kV and tube current was set to 200 mA for axial scans and 800–1050 mA for helical scans depending on the patient's habitus. A bolus tracking with region of interest in the descending aorta and a threshold of 110 HU and was used after the administration of 80 ml contrast agent (Imeron 370, Bracco Imaging Deutschland, Konstanz, Germany) at a flow rate of 6 ml/s. Image reconstruction was performed at the 75% phase for axial scans and at the optimal phase for helical scans (0–100%). The grade of diameter stenosis (maximum diameter reduction) was determined in curved multiplanar reformatted reformats by dividing the minimal diameter in the diseased segment by the mean diameter in the adjacent proximal and distal disease free section [25] using a commercially available software (Philips Extended Brilliance Workspace 4.0). Significant CAD was defined as an obstruction of ≥ 50% of at least one coronary artery segment.

Follow-up

77 of 151 patients (51%) returned to our department for one or more of the following reasons: regular cardiac check-up examinations, symptom recurrence, or occurrence of acute cardiac events. Cardiac events (acute coronary syndromes), coronary artery interventions, hospitalisation due to any cardiovascular symptoms (including chest pain, heart rhythm disorders, cardiac decompensation) and all-cause death were assessed during follow-up for further analysis. In case follow-up data was not available or follow-up was shorter than 1 year, we contacted patients per mail. After receiving consent of the patients, we conducted structured telephone interviews directly with them and/or with their physicians. In case of lacking or insufficient informations, family doctors have been interviewed or registration offices were contacted to get information as reliable as possible. Finally, high-quality follow-up data was available for 149 patients (98.7%). The study was carried out fulfilling the standards of the Ethics Committee of the University of Heidelberg and in concordance with the Declaration of Helsinki.

Statistical analysis

SPSS version 24 software (SPSS Inc., Chicago, Illinois) was used for all statistical analysis. Continuous variables were reported as mean ± standard deviation or median plus interquartile range (IQR). Normality were tested by the Shapiro-Wilk-test. Two-groups comparisons were performed by Student's *t* test or Mann–Whitney *U* test depending on normal/non-normal distribution. Dichotomous variables were expressed as absolute numbers and percentages. Frequency of the events in different groups were compared with Chi-square or Fisher's exact test. The correlation between the ESC SCORE and CAD, cardiac events and all-cause mortality were evaluated by logistic regression. The association of our echo-CCS and the Agatston score as well as the ESC SCORE were assessed by Spearman correlation. Kaplan–Meier analysis and logistic regressions were conducted to assess the prognostic value of the echo-CCS for cardiac events, coronary interventions, hospitalisation, and all-cause mortality. Logistic regressions were always performed univariate and, if possible, multivariate adjusted to age, gender and ESC SCORE. The optimal cut-off for the echo-CCS was determined by a ROC (receiver operating characteristic) analysis. 75 patients were selected randomly 3 months later and analyzed again to assess interobserver variability through Inter-Class-Correlation coefficient (ICC). A p value of < 0.05 and a confidence interval (CI) of 95% were determined in all analyses as significant.

Results

Study population

Table 1 shows the baseline characteristics of the study population. The median age was 64 years (IQR: 57.5–70.2), and 75 (49.7%) were male patients. The median ESC SCORE was 3 (IQR: 2–5), while the median Agatston score was

Table 1 Baseline characteristics of the study population ($n = 151$)

Variables	
Age in years (median and IQR)	64 (57.5–70.2)
Male gender, *n* (%)	75 (49.7)
Hypertension, *n* (%)	124 (82.1)
Hypercholesterolemia, *n* (%)	107 (70.9)
Diabetes mellitus, *n* (%)	6 (4)
Current or previous smoker, *n* (%)	33 (21.9)
Obesity, *n* (%)	27 (17.9)
Renal failure (stage ≥ 3), *n* (%)	17 (11.3)
Days between CT and echocardiography (median and IQR)	17 (9–30)
Aortic root calcification, *n* (%)	29 (19.2)
Aortic valve calcification, *n* (%)	19 (12.6)
Mitral annular calcification, *n* (%)	19 (12.6)
Papillary muscle calcification, *n* (%)	26 (17.2)
Septal calcification, *n* (%)	6 (4.0)
No CAD, *n* (%)	70 (46.4)
Nonobstructive CAD, *n* (%)	45 (29.8)
Significant CAD, *n* (%)	36 (23.8)
Agatston score, (median and IQR)	16 (0–186)
ESC SCORE (median and IQR)	3 (2–5)

CAD coronary artery disease, *IQR* interquartile range

16 (IQR: 0–186), both representing a study population of low to intermediate cardiovascular risk (Fig. 1). Follow-up data were obtainable for 149 patients (98.7%). After splitting the population into a group with echo-CCS < 2 and echo-CCS ≥ 2, patients with echo-CCS ≥ 2 were significantly older (70.6 vs. 62.2 years) and had significantly more frequently hypercholesterolemia, hypertension and CAD (Table 2). Furthermore, Table 2 demonstrates that an echo-CCS ≥ 2 goes align with a higher median Agatston score (309). Table 3a shows the events which occured during the median follow-up of 6.2 years, while the Table 3b, 3c and 3d divide those events by ESC SCORE (cut-off ≥ 5%), Agatston score (cut-off ≥ 300) and echo-CCS (cut-off ≥ 2), respectively. However, just the echo-CCS (Table 3d) is able to filter patients with significant, higher rates of cardiac events, coronary interventions, hospitalisations for cardiac symptoms and all-cause mortality.

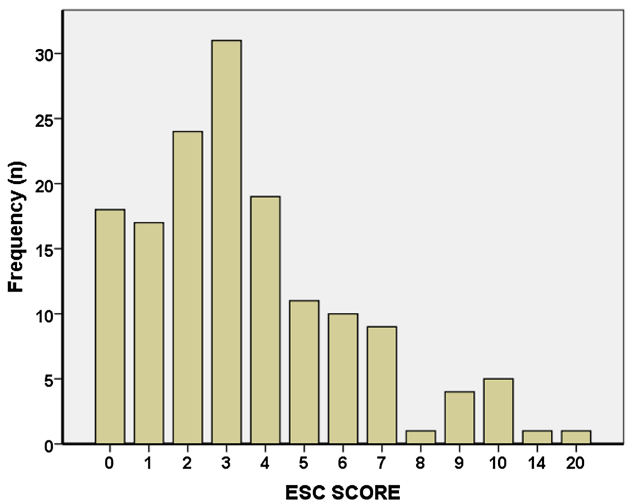

Fig. 1 Frequency and distribution of the ESC SCORE in the study population (median = 3, IQR: 2–5)

The ESC SCORE

We performed univariate logistic regressions for the ESC SCORE (Table 4). A higher ESC SCORE was associated with an increased probability of a significant CAD [OR = 1.2 (CI: 1.1–1.4); $p = 0.002$]. The predictive value was even stronger with ESC SCORE ≥ 5% [OR = 2.7 (CI: 1.2–6.0); $p = 0.01$]. However, in our study population the ESC SCORE was not a significant predictor of cardiac events. Spearman correlation showed a moderate correlation between the echo-CCS and the ESC SCORE ($\rho = 0.5$; $p < 0.001$) (Fig. 2).

The echocardiographic calcification score (echo-CCS)

The ROC optimized cutoff value for the echo-CCS was ≥ 2 (with a prevalence of 14.6% in the study population). Inter-observer variability was low (ICC = 0.82). Figure 3 shows a representative three chamber view of a patient with an echo-CCS of 3 (septal, mitral annular and aortic calcifications). Spearman´s correlation revealed a good correlation ($\rho = 0.73$, $p < 0.001$) between our echo-CCS and the conventional Agatston score (Fig. 4).

We assessed logistic regression analysis to evaluate the correlation between echo-CCS, significant CAD and future events (Table 5). Univariate regressions revealed that echo-CCS is a significant predictor for cardiac events [OR = 5.1 (CI: 1.7–15.0); $p = 0.003$], coronary intervention [OR = 2.8 (CI: 1.3–5.7); $p = 0.006$], hospitalisation for cardiac

Table 2 Baseline characteristics of patients with low (< 2) vs. higher (≥ 2) echo-CCS

Variables	Total population, *n* = 151	Echo-CCS < 2, *n* = 129 (85.4%)	Echo-CCS ≥ 2, *n* = 22 (14.6%)	*p*
Age in years (median and IQR)	64 (57.5–70.2)	62.2 (55.7–62.2)	70.6 (66.5–76.1)	< 0.01
Male gender, *n* (%)	75 (49.7)	64 (49.6)	11 (50.0)	n.s.
Hypertension, n (%)	124 (82.1)	103 (79.8)	21 (95.5)	< 0.01
Hypercholesterolemia, n (%)	107 (70.9)	88 (68.2)	19 (86.4)	0.04
Diabetes mellitus, *n* (%)	6 (4)	4 (3.0)	2 (9.1)	n.s.
Curr. or prev. smoker, *n* (%)	33 (21.9)	28 (21.7)	5 (22.7)	n.s.
Obesity, *n* (%)	27 (17.9)	23 (17.8)	4 (18.2)	n.s.
Renal failure (stage ≥ 3), *n* (%)	17 (11.3)	14 (10.9)	3 (13.6)	n.s.
No CAD, *n* (%)	70 (46.4)	70 (54.3)	0 (0)	< 0.01
Nonobstructive CAD, *n* (%)	45 (29.8)	40 (31.0)	5 (22.7)	n.s.
Significant CAD, *n* (%)	36 (23.8)	21 (16.3)	15 (68.2)	< 0.01
Agatston score (median and IQR)	16 (0-186)	4 (0–90)	309 (174–483)	< 0.01
ESC SCORE (median and IQR)	3 (2–5)	3 (1–4)	4.5 (3–7)	< 0.01

CAD coronary artery disease, *IQR* interquartile range, *curr. or prev. smoker* current or previous smoker, *n.s.* no significant differences, *SCORE* Systematic Coronary Risk Evaluation, echo-*CCS* echocardiographic calcification score

Table 3 Events during follow-up ($n = 149$)

(a) Variables	n (%)[a]		
All-cause death	10 (6.7)		
Cardiac event (ACS)	5 (3.4)		
Coronary intervention	11 (7.4)		
Hospitalisation for cardiac symptoms	30 (20.1)		
(b) Variables	**ESC SCORE < 5 ($n = 109$) n (%)[a]**	**ESC SCORE ≥ 5 ($n = 42$) n (%)[a]**	**p**
All-cause death	7 (6.4)	3 (7.1)	0.9
Cardiac event (ACS)	2 (1.8)	3 (7.1)	0.13
Coronary intervention	6 (5.5)	5 (11.9)	0.24
Hospitalisation for cardiac symptoms	18 (16.5)	12 (28.6)	0.17
(c) Variables	**Agatston score < 300 ($n = 130$) n (%)[a]**	**Agatston score ≥ 300 ($n = 21$) n (%)[a]**	**p**
All-cause death	8 (6.2)	2 (9.5)	0.53
Cardiac event (ACS)	3 (2.3)	2 (9.5)	0.13
Coronary intervention	8 (6.2)	3 (14.3)	0.16
Hospitalisation for cardiac symptoms	24 (18.5)	6 (28.6)	0.24
(d) Variables	**Echo-CCS < 2 ($n = 129$) n (%)[a]**	**Echo-CCS of ≥ 2 ($n = 22$) n (%)[a]**	**p**
All-cause death	6 (4.7)	4 (18.2)	0.04
Cardiac event (ACS)	2 (1.6)	3 (13.6)	0.01
Coronary intervention	6 (4.7)	5 (22.7)	0.004
Hospitalisation for cardiac symptoms	21 (16.3)	9 (40.9)	0.002

ACS acute coronary syndrome

[a]Follow-up available for 149 patients (98.7%)

Table 4 Correlation between ESC SCORE and CAD and mortality

Variables	Univariate logistic regression		
	OR	CI 95%	p
SCORE and significant CAD	1.2	1.1–1.4	0.002
SCORE ≥ 5% and significant CAD	2.7	1.2–6.0	0.01
SCORE and all-cause mortality	1.1	0.9–1.4	n.s.

Significant CAD coronary artery disease with stenosis ≥ 50%, *SCORE* Systematic Coronary Risk Evaluation, *OR* odds ratio, *CI* confidence interval, *n.s.* no significant differences

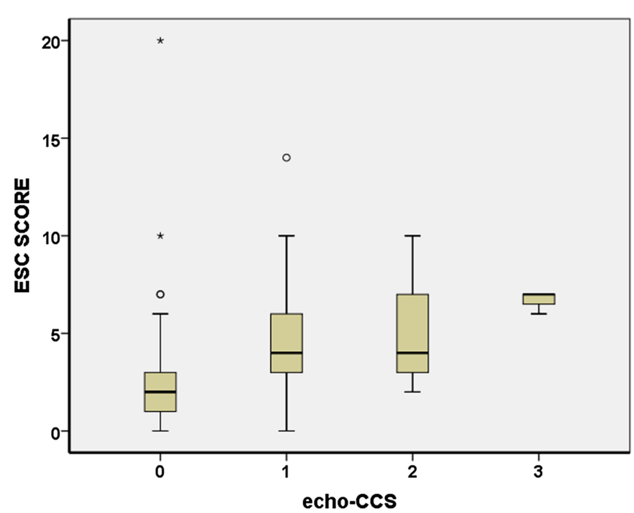

Fig. 2 Correlation between echo-CCS and ESC SCORE by using Spearman correlation ($\rho = 0.5$, $p < 0.001$)

symptoms [OR = 2.0 (CI: 1.2–3.4); $p = 0.007$], all-cause mortality [OR = 2.6 (CI: 1.3–5.5); $p = 0.01$] and significant CAD [OR = 3.2 (CI: 1.9–5.4); $p < 0.001$]. After adjustment for age, gender and ESC SCORE, echo-CCS remained an independent, significant predictor for coronary intervention [OR = 3.8 (CI = 1.4–9.9); $p = 0.007$], hospitalisation for cardiac symptoms [OR = 1.9 (CI: 1.0–3.5); $p = 0.04$] and significant CAD [OR = 2.5 (CI: 1.4–4.4); $p = 0.002$]. However, due to the low sample size and the low number of events,

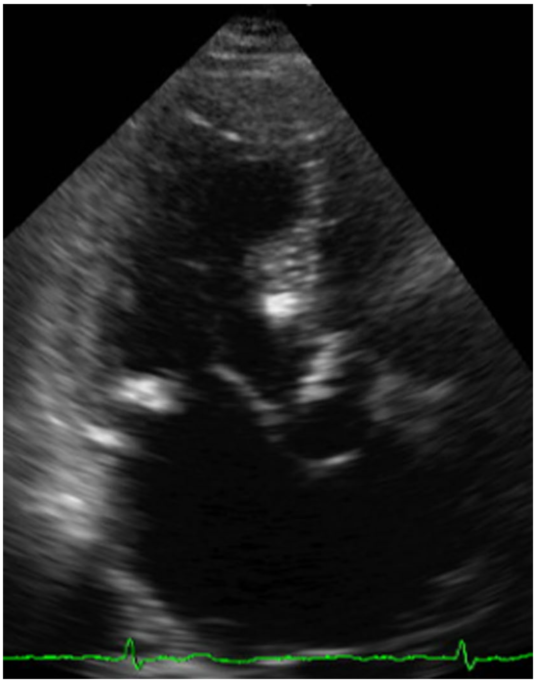

Fig. 3 Representative three chamber view of a patient with an echo-CCS of 3 (septal, mitral annular and aortic calcifications)

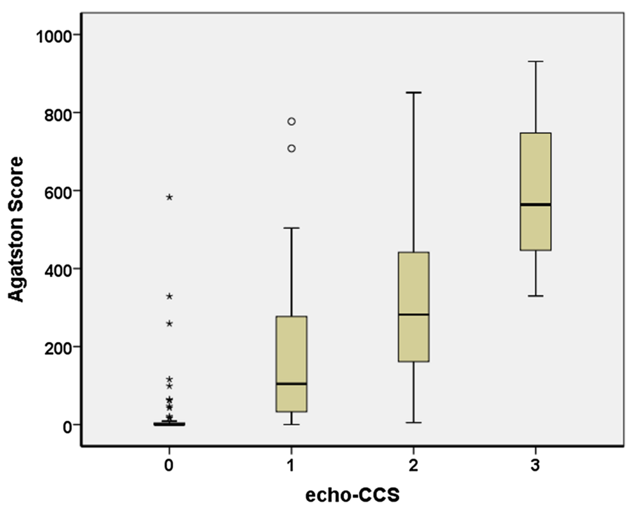

Fig. 4 Correlation between echo-CCS and Agatston score by using Spearman correlation ($\rho = 0.73$, $p < 0.001$)

the adjusted results (from the multivariate model) have to be interpreted with care.

The results of Kaplan–Meier analysis combined with Log rank test is shown on Figs. 5, 6, 7 and 8. A significant difference regarding the need for coronary intervention, occurrence of cardiac events, hospitalisation for cardiac symptoms and all-cause mortality could be shown during follow-up between patients with echo-CCS < 2 vs. echo-CCS ≥ 2.

Discussion

In the present study, the previously introduced echo-CCS including five anatomic structures of the left ventricle (aortic valve, aortic root, mitral annulus, papillary muscle and ventricular septum) was applied in a population with low/intermediate cardiovascular risk as assessed by the ESC SCORE. We could show an association of the echo-CCS with the ESC SCORE and a good correlation with the conventional Agatston score. An echo-CCS of ≥ 2 was associated with significant CAD. Furthermore, echo-CCS of ≥ 2 predicted/indicated future cardiac events, coronary interventions, hospitalisation for cardiac symptoms and increased all-cause mortality. Most importantly, patients in this study had a median ESC SCORE of 3 (< 5%) and a median Agatston score of 16 (< 300) while 14.6% of them had an echo-CCS of ≥ 2 indicating a higher CVD-risk. Thus, the echo-CCS identified patients with an increased CVD-risk in the low/intermediate cardiovascular risk group suggesting an additive value in CV risk stratification.

Current European guidelines on cardiovascular disease prevention have a class IIb level B recommendation for using coronary artery calcium CT-scoring as a risk modifier in CV risk assessment especially for individuals with calculated SCORE around the 5 or 10% thresholds [5]. The reason is the potential reclassification of these individuals in lower or higher CV risk classes which may affect patient`s management inclusive of further diagnostic and treatment strategies. The results of this study demonstrate that patients with an echo-CCS ≥ 2 had a median Agatston score of 309 and, therefore, would be considered as high cardiovascular risk patients. Furthermore, the ESC SCORE and the Agatston score failed to predict clinical end points in this study (Table 3b, c), while the echo-CCS ≥ 2 was able to sort out patients with a significant higher rate of cardiac events, coronary interventions, hospitalisations for cardiac symptoms and all-cause mortality (Table 3d). Additionally, coronary artery calcium scoring with CT is associated with potential side effects due to ionising radiation. In consequence, we think that an echo-CCS may be an easily available, cost-effective and harmless alternative to the Agatston score in CV risk assessment and risk reclassification. Therefore, it might be useful that patients with an echo-CCS ≥ 2 have a closer follow-up and more extensive control of cardiovascular risk factors.

The evaluation of our easily obtainable calcification score is an extension to former studies [17, 19, 20, 26, 30]. Although most previous studies addressing echocardiographic calcification scores evaluated aortic valve, aortic root and mitral annular calcifications, only a few

Table 5 Correlation between echo-CCS and CAD, cardiac event, coronary intervention, hospitalisation and mortality

Variables	Univariate logistic regression			Multivariate logistic regression[a]		
	OR	CI 95%	*p*	OR	CI 95%	*p*
Significant CAD	3.2	1.9–5.4	< 0.001	2.5	1.4–4.4	0.002
Cardiac event	5.1	1.7–15.0	0.003		[b]	
Coronary intervention	2.8	1.3–5.7	0.006	3.8	1.4–9.9	0.007
Hospitalisation for cardiac symptoms	2.0	1.2–3.4	0.007	1.9	1.0–3.5	0.04
All-cause mortality	2.6	1.3–5.5	0.01	2.1	0.8–5.3	0.13

Significant CAD coronary artery disease with stenosis ≥ 50%, *SCORE* Systematic Coronary Risk Evaluation, *OR* odds ratio, *CI* = confidence interval

[a]Adjusted for: age, gender and ESC SCORE

[b]*n* too low for calculation

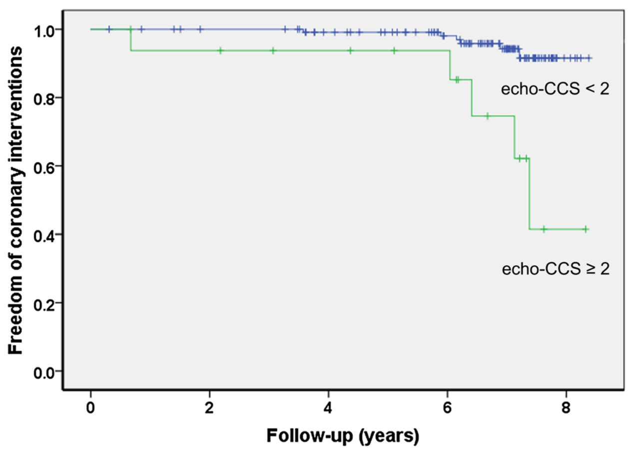

Fig. 5 Kalpan-Meier analysis for coronary interventions with a cut-off echo-CCS ≥ 2 ($p < 0.001$ with log rank test)

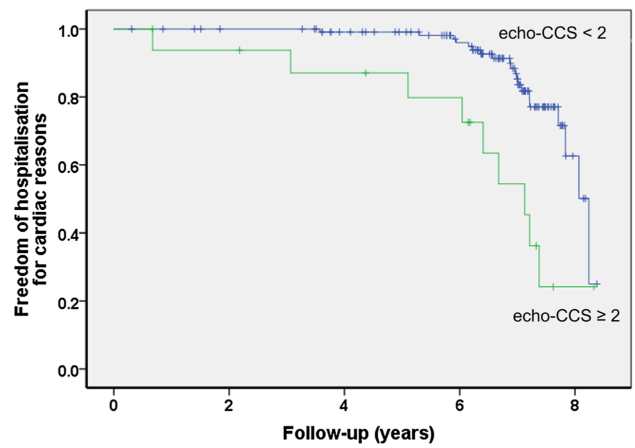

Fig. 7 Kalpan-Meier analysis for hospitalisation for cardiac symptoms with a cut-off echo-CCS ≥ 2 ($p = 0.001$ with log rank test)

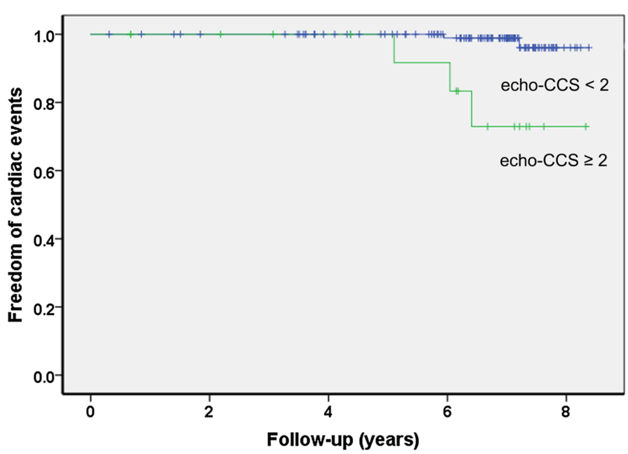

Fig. 6 Kalpan-Meier analysis for cardiac events with a cut-off echo-CCS ≥ 2 ($p < 0.001$ with log rank test)

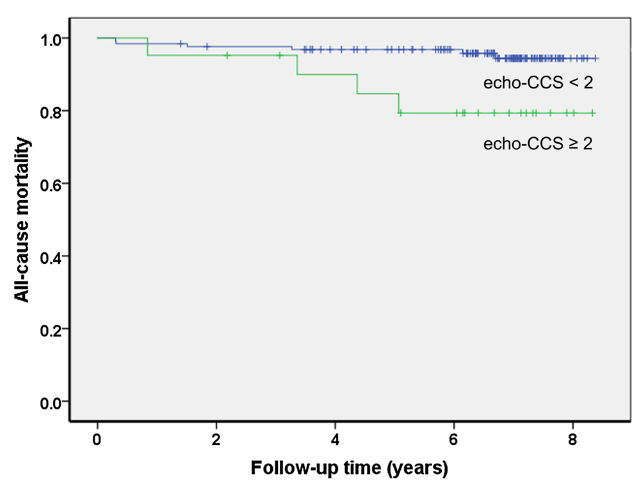

Fig. 8 Kalpan–Meier analysis for all-cause mortality with a cut-off echo-CCS ≥ 2 ($p = 0.012$ with log rank test)

studies involved the calcification of papillary muscles, although they are usually well detectable at standard echocardiography views [20, 26, 30–32]. Moreover, to our knowledge, no other published echocardiographic calcification score involved septal calcifications [26]. Although septal calcification is rare and more difficult to visualize on standard transthoracic echocardiography, it is in our opinion a valuable extension of such a calcification score. Our study population had a low/intermediate cardiovascular risk (median ESC SCORE of 3/median Agatston score of 16), resulting in a low prevalence of echocardiographically assessable calcifications; thus (in agreement with the ROC analysis) a cut-off score of 2 was selected for further risk assessment.

Our results showing a higher rate of relevant coronary artery disease in patients with more cardiac calcification are in line with several prior studies [17, 33–35]. All-cause mortality was significantly higher in the patient group with a higher calcification score (≥ 2), similarly to the results of other studies [25, 36]. A higher rate of future cardiac events in patients with an echo-CCS ≥ 2 could be shown as well. Two recent studies provided important data on the prognostic value of semi-quantitative echocardiographic calcium scoring, both of them involved papillary muscle calcification as well. Gaibazzi et al. showed for the first time in a multicenter cohort with suspected CAD that their echocardiographic calcification score independently contributed to risk prediction more than clinical variables alone. Their work supported the hypothesis that an echocardiographic calcification score may be used as a risk modifier analog to the calcium scoring with CT [31]. Lu et al., assess a semiquantitative calcium score assessed by echocardiography that showed a significant and independent association with total mortality. However, their study population comprised mainly patients at a high cardiovascular risk as reflected by the high proportion of fatal outcomes [32]. In contrast to both studies, our trial focused on patients with low/intermediate CV risk. In this population, the prognostic value of the echocardiographic calcium scoring could be confirmed which is an important addition to the previous studies [31, 32].

Although, at present, cardiac CT is the reference standard to directly detect and quantify coronary artery and cardiac calcification, the high cost of equipment, the radiation exposure and the inability to perform bedside testing limit its use on a routine basis [37]. A easily obtainable echocardiographic calcification score may especially be used for non-invasive, inexpensive and side-effect free risk stratification, when routine non-invasive diagnostic modalities do not provide enough information for cardiac risk evaluation in the asymptomatic patient.

Limitations

This study is limited by its single center, retrospective design, although it involves follow-up data of a very high proportion of the patients due to several contacting methods. All subjects were referred for CTA and echocardiography on the basis of an appropriate clinical indication, representing a possible source of bias. A prospectively designed study would be necessary to further support the findings in this study.

Conclusions

An easy to conduct echocardiographic cardiac calcification score obtained in a patient population with low/intermediate cardiovascular risk showed an association with the ESC SCORE and a good correlation with the conventional Agatston score. Furthermore, echo-CCS was remarkably associated with significant CAD and it was able to predict cardiac events, coronary interventions, hospitalisations for cardiac symptoms and all-cause mortality. The strong association with CT-calcium scoring may evoke its potential as an alternative method in CV risk assessment.

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Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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