JAMA Cardiology | Original Investigation

CT Angiography, Healthy Lifestyle Behaviors, and Preventive Therapy
A Nested Substudy of the SCOT-HEART 2 Randomized Clinical Trial

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IMPORTANCE Healthy lifestyles and uptake of primary preventive therapies for cardiovascular disease remain poor.

OBJECTIVE To determine the impact of coronary computed tomography (CT) angiography on healthy lifestyle behaviors, acceptance of recommended treatments, and modification of risk factors as compared with guideline-directed cardiovascular risk scoring.

DESIGN, SETTING, AND PARTICIPANTS This was a nested substudy conducted from September 2020 to August 2024 of a randomized clinical trial where participants underwent cardiovascular risk scoring or coronary CT angiography. Primary care–based screening took place in Scotland. Included in the analysis were asymptomatic individuals aged 40 to 70 years without known cardiovascular disease and with at least 1 cardiovascular risk factor. Study data were analyzed from August to September 2024.

INTERVENTIONS All participants received lifestyle advice with additional recommendations for moderate-intensity statin therapy if the 10-year cardiovascular risk was greater than or equal to 10% or combined antiplatelet and at least moderate-intensity statin therapies if coronary atherosclerosis was identified on CT angiography.

MAIN OUTCOMES AND MEASURES The composite primary outcome was compliance with the National Institute for Health and Care Excellence recommendations for diet, body mass index, smoking, and physical exercise at 6 months.

RESULTS Between September 2020 and January 2024, 400 participants were enrolled (median [IQR] age, 62 [56-65] years; 198 female [49.5%]; median [IQR] 10-year cardiovascular risk, 14% [9%-19%]) with 195 randomized to cardiovascular risk scoring and 205 to coronary CT angiography. At 6 months, those who underwent CT angiography were more likely to meet the primary composite end point (17% [33 of 194 participants] vs 6% [10 of 177 participants]; odds ratio, 3.42; 95% CI, 1.63-6.94; $P < .001$). Compared with cardiovascular risk scoring, fewer participants were recommended preventive therapy after CT angiography (51% [105 of 205 participants] vs 75% [147 of 195 participants]; $P < .001$), but acceptance of recommendations was higher (77% [81 of 105 participants] vs 46% [68 of 147 participants]; $P < .001$). This resulted in similar use of lipid-lowering therapy (44% [90 of 205 participants] vs 35% [69 of 195 participants]; OR, 1.43; 95% CI, 0.96-2.15; $P = .08$) and greater use of antiplatelet therapy in those randomized to CT angiography (40% [83 of 205 participants] vs 0.5% [1 of 195 participants]; $P < .001$). Participants randomized to coronary CT angiography had small incremental improvements in risk factors and 10-year cardiovascular risk, largely driven by those with CT-defined coronary atheroma.

CONCLUSIONS AND RELEVANCE Results of this cohort study reveal that compared with cardiovascular risk scoring, coronary CT angiography was associated with modest improvements in healthier lifestyle behaviors, acceptance of recommended preventive therapy, and risk factor modification. Whether this strategy reduces coronary events remains to be established.

JAMA Cardiol. doi:10.1001/jamacardio.2025.1763
Published online June 18, 2025.

Editorial
Supplemental content

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Cardiovascular disease continues to be the leading cause of morbidity and mortality in the Western world causing substantial loss of economic productivity and accounting for 1 in 7 deaths.[1-3] The current strategy to prevent cardiovascular disease focuses on the promotion of lifelong healthy lifestyle behaviors, optimization of an individual's cardiovascular risk profile, and stratifying individuals using cardiovascular risk scores to guide primary prevention.[4,5]

Although cardiovascular risk scores are used globally and are recommended by international guidelines,[4,5] they have a number of important limitations, and definitive evidence from randomized clinical trials to support their use is lacking.[6] They are imprecise and commonly overestimate and underestimate cardiovascular risk, particularly in younger and older individuals, respectively.[7-10] Scores are also often misinterpreted, resulting in an inaccurate perception of cardiovascular risk.[11,12] This may reduce motivation to pursue positive lifestyle behaviors and result in a reluctance to initiate or continue preventive medication.[12,13]

Coronary computed tomography (CT) angiography is not currently recommended to guide primary prevention, although it can definitively detect or refute the presence of subclinical coronary artery atherosclerosis. The ongoing Scottish Computed Tomography of the Heart (SCOT-HEART) 2 trial has been designed to evaluate whether screening for coronary artery disease with coronary CT angiography leads to a reduction in coronary heart disease death or nonfatal myocardial infarction when compared with a cardiovascular risk scoring approach.[14] In this nested substudy within the SCOT-HEART 2 trial, we aimed to evaluate the impact of coronary CT angiography on the adoption of healthy lifestyle behaviors, uptake of preventive treatment, and modification of risk factors compared with using cardiovascular risk scores. Furthermore, in those randomized to CT angiography, we aimed to evaluate whether direct visualization of an individual's imaging findings conferred additional benefit with regard to the primary and secondary outcomes.

Key Points

Question Compared with cardiovascular risk scoring, is coronary computed tomography (CT) angiography associated with better lifestyle behaviors, enhanced acceptance of preventive therapies, and improved risk factor modification?

Findings In this nested substudy of a randomized clinical trial including 400 individuals, participants undergoing CT angiography were more likely to achieve healthier lifestyle behaviors, initiate recommended preventive therapies, and attain lower serum cholesterol concentrations and blood pressure, especially in those identified with coronary atheroma.

Meaning Results suggest that CT angiography–guided cardiovascular disease prevention was associated with an increase in healthier lifestyles, acceptance of preventive therapies, and beneficial risk factor modification; whether this is associated with a reduction in coronary events compared with cardiovascular risk scoring remains to be established.

Methods

Study Design and Participants

The SCOT-HEART 2 impact trial[15] is a nested substudy of the SCOT-HEART-2 trial (eMethods in Supplement 1). The study was approved by the North of Scotland Research Ethics Committee. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines.

Individuals enrolled within the main SCOT-HEART 2 trial were invited to participate in this substudy and provided written informed consent at their baseline visit. The rationale and design of the SCOT-HEART 2 trial has been described previously.[14] In brief, the SCOT-HEART 2 trial[16] is an open-label, parallel-group, randomized clinical trial that compares cardiovascular risk scoring with screening for coronary atherosclerosis using coronary CT angiography for the primary prevention of myocardial infarction. Participants were asymptomatic individuals aged between 40 and 70 years without known cardiovascular disease but with 1 or more cardiovascular risk factors. Neither race nor ethnicity was collected for this nested substudy.

Baseline and 6-Month Visits

At baseline and 6-month visits, participants had their height, weight, body mass index, waist circumference, 24-hour ambulatory blood pressure (or an average of home blood pressure readings over 7 days), daily step count using a pedometer (averaged from the preceding 7 days), lipid profile, glycated hemoglobin (HbA_{1c}), and cardiovascular risk score recorded by the study physician (M. McDermott, P.K., M. Meah). Step count and ambulatory or home blood pressure recordings were obtained in the days immediately after both baseline and 6-month visit. Participants completed a questionnaire on their level of education, income, diet, smoking status (confirmed by measuring expired carbon monoxide), self-reported activity (International Physical Activity Questionnaire), and mental well-being (Patient Health Questionnaire 9). The SCOT-HEART 2 Lifestyle Questionnaire is available in the eAppendix in Supplement 1.

Study Procedure

All participants in the study received a structured consultation with a study physician to promote a healthy lifestyle as outlined by the European Society of Cardiology and National Institute for Health and Care Excellence (NICE) guidelines at the baseline visit.[4,17] For individuals randomized to coronary CT angiography, this consultation occurred before their scan. Participants and their primary care practitioner received a letter with their cardiovascular risk score or coronary CT angiography results, with all prescriptions issued by the participant's primary care physician.

Cardiovascular Risk Score

Participants had their 10-year cardiovascular risk calculated using the ASSIGN cardiovascular risk score.[18] The ASSIGN score is a 10-year cardiovascular risk score that has been calibrated for the Scottish population. Participants with a score less than 10% are deemed low risk, and those with a score of 10% or greater are considered eligible for lipid-lowering therapy (atorvastatin, 20 mg, daily or equivalent).

Coronary CT Angiography

Participants randomized to coronary CT angiography had their recommendation for preventive therapy based on their CT findings alone.[14] Those with normal coronary arteries were recommended no primary preventive therapies. Those with nonobstructive coronary artery disease were recommended antiplatelet (aspirin or clopidogrel, 75 mg, daily) and lipid-lowering (atorvastatin, 20 mg, daily or equivalent) therapies. Participants with obstructive coronary artery disease (>50% stenosis of the left main stem or >70% stenosis of an epicardial coronary artery) were recommended to have antiplatelet, high-intensity lipid-lowering therapy (atorvastatin, 80 mg, daily or equivalent) and consideration for angiotensin-converting enzyme inhibitor therapies.[19,20]

Participants randomized to coronary CT angiography were further randomized to determine how their results were shared: verbal report or visualization of their CT angiogram. Participants randomized to receive a verbal report of their CT angiogram had their results explained in a structured manner on the day of their scan. Participants randomized to visualize their coronary CT angiogram reviewed their images with a reporting clinician and their findings explained to them in lay terms.

Outcomes

The primary composite outcome was the proportion of participants who achieved all NICE recommendations for diet, body mass index, smoking, and physical exercise (eTable 1 in Supplement 1).[21] Secondary outcomes were the components of the primary outcome, changes in weight, waist circumference, blood pressure, lipid profile, HbA_{1c} level, step count, mental well-being, and 10-year cardiovascular risk score. The initiation of preventive therapies was recorded using self-reported questionnaires and electronic prescribing data.

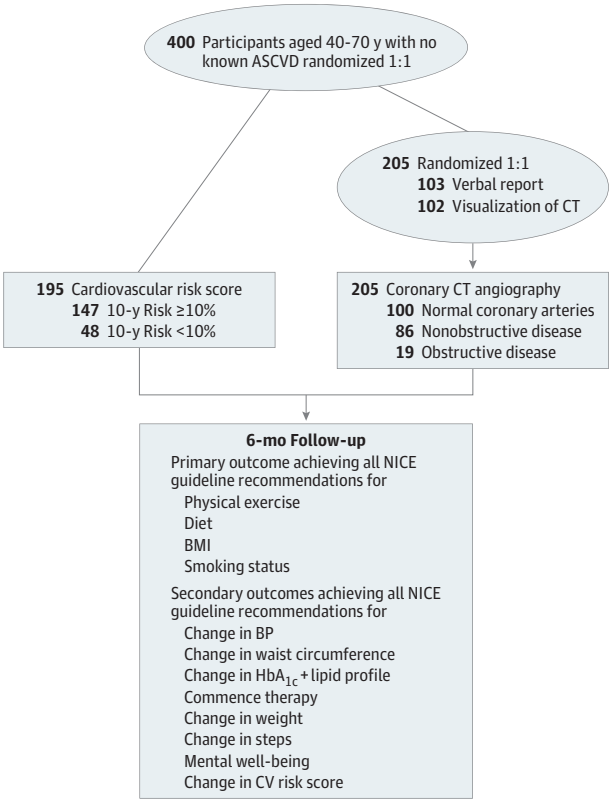
Statistical Analysis

Based on observational data,[22] we anticipated that 5% of participants randomized to cardiovascular risk scoring would meet the composite primary outcome. To have a meaningful impact, we considered that CT angiography would need to translate into improved compliance of at least 1 in 10 participants (15% total). For 90% power with a 2-sided α of .05, we required 187 participants per treatment arm. Participant dropout was taken into account when estimating recruitment numbers, and given that this was an open-label study and the primary end point was self-reported, we also considered power of the study for an objective measure of risk factor modification. Sample size had to have 90% power at a 2-sided significance level of 5% to detect a mean difference in plasma total cholesterol concentrations of 10%.[23]

Descriptive characteristics are presented as numbers and percentage and continuous variables as median (IQR). All outcomes were evaluated by the main trial randomization and by cardiovascular risk in each group (eMethods in Supplement 1). For participants randomized to CT angiography, outcomes were also evaluated by those randomized to receive a verbal report or to visualize their images.

Outcomes were assessed using Mann-Whitney *U* and Kruskal-Wallis test for continuous variables and Pearson χ^2 test for categorical variables. A 2-sided *P* value <.05 was considered statistically significant. All data analysis was conducted from August to September 2024 using Prism 10, version 10.3.0 (GraphPad).

Figure 1. The Design of the Scottish Computed Tomography of the Heart (SCOT-HEART) 2 Impact Study



Moderate-intensity statin included atorvastatin, 20 mg, daily or equivalent, with high-intensity statin being atorvastatin, 80 mg, daily or equivalent. Aspirin, 75 mg, daily was the default antiplatelet agent. To achieve the primary outcome, participants had to achieve all of the following: a body mass index (BMI) of 18.5 to 25 (calculated as weight in kilograms divided by height in meters squared), eat 5 fruits and vegetables daily and oily fish twice per week, be a nonsmoker, and undertake 150 minutes of moderate intensity or 75 minutes of vigorous intensity aerobic physical activity a week at minimum. ASCVD indicates atherosclerotic cardiovascular disease; BP, blood pressure; CT, computed tomography; CV, cardiovascular; HbA_{1C}, glycated hemoglobin; NICE, National Institute for Health and Care Excellence.

Results

Study Population

Between September 2020 and January 2024, 400 participants were enrolled (median [IQR] age, 62 [56-65] years; 198 female [49.5%]; 202 male [50.5%]); 205 participants were randomized to coronary CT angiography, and 195 were randomized to cardiovascular risk scoring (**Figure 1** and **Table 1**). One participant randomized to the cardiovascular risk score group underwent a coronary CT angiogram. The groups were similar at baseline.

Table 1. Baseline Characteristics of Study Populations

Characteristic	Group	
	Coronary CT angiogram	Cardiovascular risk score
Total No.	205	195
Age, median (IQR), y	62 (58-65)	62 (56-65)
Female, No. (%)	105 (51)	93 (48)
Male, No. (%)	100 (49)	102 (52)
Education, No. (%)		
Secondary school	42 (21)	39 (20)
College	46 (22)	48 (25)
University	117 (57)	108 (55)
Income, No. (%), $		
<40 000	80 (39)	71 (36)
40 000-65 000	63 (31)	65 (33)
>65 000	62 (31)	59 (30)
Anthropometric data, median (IQR)		
Weight, kg	81 (69-93)	83 (70-94)
Body mass index[a]	28 (25-32)	28 (26-32)
Waist circumference, cm	93 (84-104)	97 (85-106)
Smoking status, No. (%)		
Current	10 (5)	17 (9)
Former	36 (18)	35 (18)
Never	159 (78)	143 (73)
Activity, median (IQR)		
Step count (per day)	7673 (4996-9778)	7601 (5000-10 500)
Self-reported activity, METS	2640 (1386-4464)	2556 (1386-4104)
Mental well-being, median (IQR)		
Depression score (PHQ-9)	2.0 (1.0-5.0)	2.0 (0.5-4.0)
Medication, No. (%)		
Antiplatelet therapy	3 (2)	1 (1)
Lipid-lowering therapy	22 (11)	34 (17)
RAAS inhibitor	29 (14)	21 (11)
Ambulatory blood pressure, median (IQR)		
Systolic, mm Hg	124 (115-130)	123 (114-131)
Diastolic, mm Hg	74 (70-80)	75 (69-81)
Biochemistry, median (IQR)		
Total cholesterol, mmol/L	5.7 (5.1-6.6)	5.7 (4.9-6.5)
LDL cholesterol, mmol/L	3.3 (2.8-4.1)	3.3 (2.7-4.0)
HDL cholesterol, mmol/L	1.5 (1.3-1.8)	1.5 (1.2-1.8)
Triglycerides, mmol/L	1.6 (1.1-2.2)	1.5 (1.1-2.2)
Glycemic control, median (IQR)		
Hemoglobin A_{1c}, mmol/mol	38 (35-40)	37 (35-39)
10-y Cardiovascular risk, median (IQR)		
ASSIGN score, %	13 (9-19)	15 (10-19)

Abbreviations: ASSIGN, Scottish 10-year cardiovascular risk score; CT, computed tomography; HDL, high-density lipoprotein; LDL, low-density lipoprotein; METS, metabolic equivalents; PHQ-9, Patient Health Questionnaire 9; RAAS, renin-angiotensin-aldosterone system.

SI conversion factor: To convert total, LDL, and HDL cholesterol to milligrams per deciliter, divide by 0.0259; triglycerides to milligrams per deciliter, divide by 0.0113.

[a] Calculated as weight in kilograms divided by height in meters squared.

The median (IQR) 10-year cardiovascular risk was 15% (10%-19%) in those randomized to cardiovascular risk scores and 13% (9%-19%) in those randomized to CT angiography.

Coronary CT angiography identified normal coronary arteries in 49% (100 of 205 participants), nonobstructive disease in 42% (86 of 205 participants), and obstructive disease in 9% (19 of 205 participants). In participants with normal coronary arteries, 55% (55 of 100) had a 10-year cardiovascular risk greater than or equal to 10%, and in those with coronary atherosclerosis, 18% (19 of 105) had a 10-year cardiovascular risk of less than 10%.

Primary Outcome

Data for the primary outcome were complete in 95% (194 of 205 participants) in the coronary CT angiography group and 91% (177 of 195 participants) in the 10-year cardiovascular risk score group. In those participants randomized to care guided by coronary CT angiography, 17% (33 of 194) achieved the composite primary outcome, satisfying all NICE recommendations for diet, body mass index, smoking, and physical exercise compared with 6% (10 of 177) of those randomized to cardiovascular risk scoring (odds ratio [OR], 3.42; 95% CI, 1.63-6.94; *P* <.001) (**Table 2**). Participants randomized to coronary CT angiography were more likely to achieve a healthy body mass index and comply with dietary advice than those in the cardiovascular risk score group. Nonsmoking status and self-reported physical exercise were high in both groups, but there were no differences in these outcomes between groups at 6 months.

Recommendation for Preventive Therapy

Of participants randomized to cardiovascular risk scoring, 75% (147 of 195) had a 10-year cardiovascular risk score greater than or equal to 10% and received a recommendation to commence preventive therapy (Table 2). In comparison, 51% (105 of 205 participants) randomized to coronary CT angiography had coronary atheroma and received a recommendation to commence preventive therapy (OR, 0.34; 95% CI, 0.23-0.53; *P* <.001). At 6 months, participants who underwent coronary CT angiography were more likely to initiate the recommended preventive therapy (77% [81 of 105] vs 46% [68 of 147]; OR, 3.86; 95% CI, 2.18-6.83; *P* <.001). This resulted in a similar proportion of participants commencing lipid-lowering treatment in each arm of the study (44% [90 of 205] in the CT angiography group vs 35% [69 of 195] in the cardiovascular risk scoring group; OR, 1.43; 95% CI, 0.96-2.15; *P* =.08). There was also greater use of antiplatelet therapy in those randomized to CT angiography (40% [83 of 205 participants]) vs 0.5% (1 of 195 participants; *P* < .001).

Although we did not measure adherence to preventive therapies, in a post hoc analysis of participants who had accepted the initiation of preventive therapy, total cholesterol, low-density lipoprotein cholesterol, and triglyceride concentrations were substantially reduced at 6 months compared with those who did not initiate therapy (eTable 2 in Supplement 1).

Secondary Outcomes

Participants randomized to preventive therapy guided by coronary CT angiography had greater improvements in weight,

Table 2. Primary and Secondary Outcomes at 6 Months

Outcome	Group		*P* value
	Coronary CT angiogram	Cardiovascular risk score	
Primary outcome,[a] No. (%)	33 (17)	10 (6)	<.001
Components of primary outcome, No. (%)			
Diet compliance	92 (47)	63 (36)	.03
Nonsmoker	188 (96)	167 (93)	.20
Body mass index 18.5-25[b]	60 (31)	38 (21)	.04
Physical exercise	123 (63)	110 (63)	.90
Anthropometric data, median (IQR)			
Δ Weight, kg	−0.9 (−3.2 to 0.8)	−0.2 (−2.4 to 1.4)	.009
Δ Body mass index[b]	−0.3 (−1.1 to 0.3)	−0.1 (−0.9 to 0.5)	.03
Δ Waist circumference, cm	−2.0 (−5.0 to 0)	−0.3 (−3.9 to 2)	.002
Physical activity, median (IQR)			
Δ Step count, steps	1026 (−126 to 3127)	83 (−1026 to 1860)	<.001
Δ Self-reported activity, METS	342 (−882 to 1386)	153 (−828 to 1173)	.60
Mental well-being, median (IQR)			
Δ Depression score (PHQ-9)	−1 (−3 to 0)	0 (−2 to 1)	.06
Medication at follow-up, No. (%)			
Preventive therapy recommended	105 (51)	147 (75)	<.001
Accepting study recommendation (initiation or cessation of preventive therapy)	176 (86)	113 (58)	<.001
Antiplatelet therapy	83 (40)	1 (0.5)	<.001
Lipid-lowering therapy	90 (44)	69 (35)	.08
Moderate-intensity statin	71 (35)	69 (35)	.60
High-intensity statin	19 (9)	0	NA
RAAS inhibitor therapy	40 (20)	24 (12)	.06
Ambulatory blood pressure, median (IQR)			
Δ Systolic, mm Hg	−1 (−7 to 2)	−1 (−5 to 3)	.11
Δ Diastolic, mm Hg	−3 (−6 to 1)	−1 (−4 to 2)	.01
Δ Mean, mm Hg	−2 (−6 to −1)	−1 (−4 to 2)	.02
Lipid profile, median (IQR)			
Δ Total cholesterol, mmol/L	−0.7 (−1.8 to 0.0)	−0.4 (−1.3 to 0.1)	.008
Δ LDL cholesterol, mmol/L	−0.5 (−1.5 to −0.1)	−0.3 (−1.0 to 0.1)	.005
Δ HDL cholesterol, mmol/L	0.0 (−0.1 to 0.2)	0.0 (−0.1 to 0.1)	.20
Δ Triglycerides, mmol/L	−0.2 (−0.8 to 0.1)	−0.2 (−0.7 to 0.2)	.50
Glycemic control, median (IQR)			
Δ Hemoglobin A_{1c}, mmol/mol	0 (−1 to 1)	1 (−1 to 2)	.20
10-y Cardiovascular risk, median (IQR)			
Δ ASSIGN score, %	−1 (−4 to 1)	0 (−3 to 2)	.008

Abbreviations: ASSIGN, Scottish 10-year cardiovascular risk score; CT, computed tomography; Δ, change in; HDL, high-density lipoprotein; LDL, low-density lipoprotein; METS, metabolic equivalents; NA, not available; PHQ-9, Patient Health Questionnaire 9; RAAS, renin-angiotensin-aldosterone system.

SI conversion factor: To convert total, LDL, and HDL cholesterol to milligrams per deciliter, divide by 0.0259; triglycerides to milligrams per deciliter, divide by 0.0113.

[a] The primary outcome was the proportion of participants who achieved all National Institute for Health and Care Excellence recommendations for diet, body-mass index, smoking, and physical exercise levels.

[b] Calculated as weight in kilograms divided by height in meters squared.

body mass index, waist circumference, diastolic blood pressure, mean arterial pressure, total cholesterol concentration, low-density lipoprotein cholesterol concentration, and a greater increase in average daily step count than those in the cardiovascular risk score group (Table 2). No differences were observed in mental well-being, systolic blood pressure, high-density lipoprotein cholesterol concentration, triglyceride concentration, or HbA_{1c} concentration.

When participants were further stratified according to the findings from CT angiography and cardiovascular risk scoring, greater differences were seen in participants with coronary atheroma on CT angiography compared with those with cardiovascular risk score greater than or equal to 10%. Participants with coronary atheroma had greater reductions in weight, body mass index, waist circumference, blood pressure, total and low-density lipoprotein cholesterol concentrations, and greater improvements in daily step count (**Table 3** and **Figure 2**).

At 6 months, participants in both groups had their cardiovascular risk score recalculated. Compared with baseline, the CT angiography group had a reduction in their 10-year cardiovascular risk from 13% (95% CI, 9%-19%) to 11% (95% CI, 8%-16% with a median Δ of −1% [95% CI, −4% to 1%]; $P < .001$), whereas no change was observed in those randomized to cardiovascular risk scoring (Table 2). This reduction was greater in participants with coronary atherosclerosis on coronary CT angiography (median [IQR], 17% [11%-22%] to 11% [8%-16%] with a median [IQR] Δ of −4% [−7% to 0%]; $P < .001$), which was greater than the reduction observed in those with a 10-year cardiovascular risk score greater than or equal to 10% (median [IQR], 17% [13%-21%] to 16% [12%-19%] with a median

Table 3. Changes in Primary and Secondary Outcome Measures at 6 Months by Subgroups

Variable	Coronary CT angiography		Cardiovascular risk score		*P* value[a]	*P* value[b]	*P* value[c]
	No atheroma	Atheroma	<10%	≥10%			
No.	100	105	48	147			
Age, median (IQR), y	62 (58 to 64)	62 (57 to 65)	55 (47 to 60)	63 (60 to 66)	<.001	.20	<.001
Female, No. (%)	70 (70)	35 (33)	33 (69)	60 (41)	<.001	.20	.90
Male, No. (%)	30 (30)	70 (67)	15 (31)	87 (59)			
Composite primary end point, No. (%)	16 (17.0)	17 (17.0)	4 (9.1)	6 (4.5)	.006	.001	.20
Dietary compliance	41 (41)	51 (51)	15 (34)	48 (36)	.09	.02	.30
Nonsmoker	93 (98)	95 (95)	43 (96)	124 (93)	.40	.40	.60
Body mass index 18.5-25[d]	31 (33)	29 (29)	14 (32)	24 (18)	.04	.045	.90
Physical exercise	53 (56)	70 (70)	28 (64)	82 (62)	.30	.20	.50
Anthropometric data, median (IQR)							
Δ Weight, kg	−0.4 (−2.5 to 1.1)	−1.4 (−4.1 to 0.3)	0.0 (−0.8 to 2.3)	−0.4 (−2.6 to 1.3)	<.001	.005	.06
Δ Body mass index[d]	−0.2 (−0.9 to 0.4)	−0.5 (−1.3 to 0.1)	0.0 (−0.4 to 0.7)	−0.2 (−0.9 to 0.4)	.006	.01	.13
Δ Waist circumference, cm	−1.0 (−4.0 to 1.0)	−3.0 (−6.0 to 0.0)	0.0 (−2.2 to 2.0)	−0.5 (−4.0 to 2.0)	.003	.001	.07
Physical activity, median (IQR)							
Δ Step count, steps	800 (−738 to 2585)	1662 (285 to 3980)	165 (−1036 to 1427)	73 (−1026 to 1894)	<.001	<.001	.20
Δ Self-reported activity, METS	136 (−693 to 1307)	350 (−1276 to 1410)	99 (−1232 to 489)	244 (−794 to 1370)	.90	.80	.20
Mental well-being, median (IQR)							
Depression score (PHQ-9)	−1 (−3 to 0)	0 (−3 to 0)	0 (−1 to 1)	0 (−2 to 0)	.14	.50	.03
Preventive therapy, No. (%)							
Preventive therapy recommended	0	105 (100)	0	147 (100)	<.001	>.99	NA
Accepting recommendation	95 (95)	81 (77)	45 (94)	68 (46)	<.001	<.001	.70
Antiplatelet therapy	2 (2)	81 (77)	0	1 (1)	<.001	<.001	>.99
Lipid-lowering therapy	3 (3)	87 (83)	7 (15)	62 (42)	<.001	<.001	.01
RAAS inhibitor therapy	15 (15)	25 (24)	7 (15)	17 (12)	.12	.02	.95
Ambulatory blood pressure, median (IQR)							
Δ Systolic, mm Hg	−1 (−7 to 3)	−4 (−8 to 2)	−3 (−5 to 2)	0 (−4 to 3)	.05	.008	.30
Δ Diastolic, mm Hg	−1 (−5 to 3)	−4 (−7 to 0)	−1 (−4 to 3)	−1 (−4 to 2)	.002	<.001	.80
Δ Mean arterial pressure, mm Hg	−2 (−5 to 3)	−4 (−7 to 0)	−1 (−5 to 1)	0 (−4 to 2)	.008	<.001	.80
Lipid profile, median (IQR)							
Δ Total cholesterol, mmol/L	−0.1 (−0.7 to 0.2)	−1.7 (−2.5 to −0.9)	−0.1 (−0.6 to 0.2)	−0.5 (−1.7 to 0.0)	<.001	<.001	.70
Δ LDL cholesterol, mmol/L	−0.2 (−0.5 to 0.1)	−1.4 (−2.1 to −0.5)	−0.2 (−0.5 to 0.3)	−0.4 (−1.2 to 0.0)	<.001	<.001	.50
Δ HDL cholesterol, mmol/L	0.0 (−0.1 to 0.2)	0.1 (−0.1 to 0.2)	0.1 (−0.1 to 0.2)	0.0 (−0.1 to 0.1)	.04	.02	.40
Δ Triglycerides, mmol/L	0.0 (−0.5 to 0.3)	−0.4 (−1.1 to −0.1)	−0.1 (−0.5 to 0.2)	−0.2 (−0.8 to 0.2)	<.001	.007	.50
Glycemic control, median (IQR)							
Δ Hemoglobin A_{1c}, mmol/mol	0 (−1 to 2)	1 (−1 to 1)	0 (0 to 1)	1 (−1 to 2)	.90	.70	.30
Overall cardiovascular risk, median (IQR)							
Δ ASSIGN score, %	0 (−1 to 1)	−4 (−7 to 0)	0 (−1 to 1)	−1 (−4 to 2)	<.001	<.001	.30

Abbreviations: ASSIGN, Scottish 10-year cardiovascular risk score; CT, computed tomography; Δ, change in; HDL, high-density lipoprotein; LDL, low-density lipoprotein; METS, metabolic equivalents; NA, not available; PHQ-9, Patient Health Questionnaire 9; RAAS, renin-angiotensin-aldosterone system.

SI conversion factor: To convert total, LDL, and HDL cholesterol to milligrams per deciliter, divide by 0.0259; triglycerides to milligrams per deciliter, divide by 0.0113.

[a] *P* value comparing all 4 groups with Kruskal-Wallis test for continuous variables, or Pearson χ^2 test for categorical variables.

[b] *P* value comparing those identified as high risk in each group (cardiovascular risk score ≥10% or those with coronary atheroma by CT coronary angiography [Mann-Whitney *U* testing]).

[c] *P* value comparing those identified as low risk in each group (cardiovascular risk score <10% or those with no coronary atheroma by CT coronary angiography [Mann-Whitney *U* testing]).

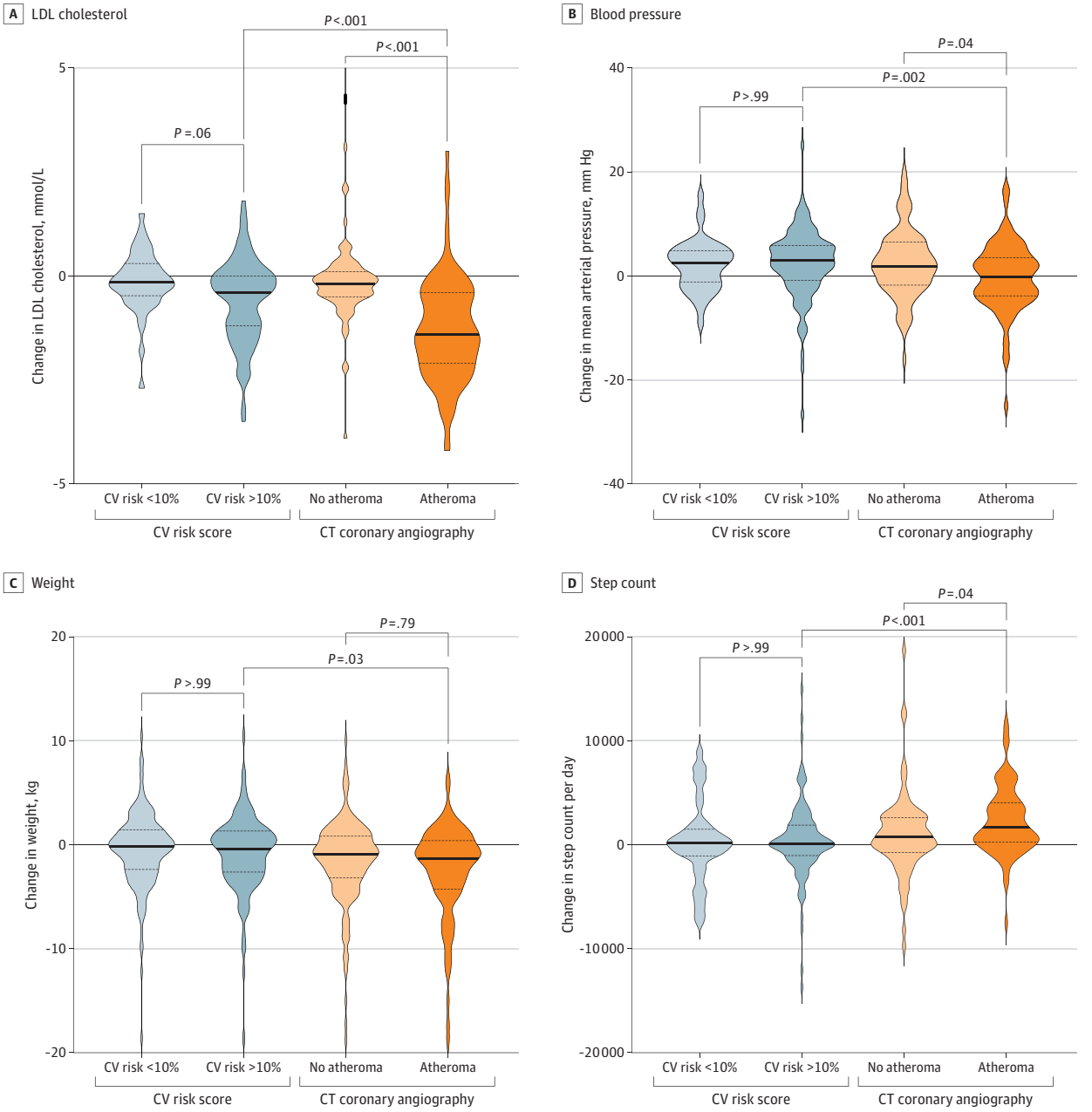
[d] Calculated as weight in kilograms divided by height in meters squared.

[IQR] Δ of −1% [−4% to 2%]; $P = .009$) (Table 3). No change was observed in cardiovascular risk score in those with normal coronary arteries or in those with a 10-year cardiovascular risk score less than 10% (Table 3).

Visualization of Coronary CT Angiography

In the coronary CT angiography cohort, 103 of 205 participants received a verbal report from the attending clinician, and 102 of 205 participants visualized their CT images with the

Figure 2. Effect of Coronary Computed Tomography (CT) Angiography and Cardiovascular Risk Score on Selected Cardiovascular Risk Factors



Six-month change in low-density lipoprotein (LDL) cholesterol (A); blood pressure (mean arterial blood pressure) (B); weight (C); and step count (D) by cardiovascular (CV) risk score.

attending clinician. No differences were observed across these 2 subgroups with regard to the primary or secondary outcomes (eTables 3 and 4 in Supplement 1).

Discussion

In asymptomatic individuals at risk of cardiovascular disease, coronary CT angiography identifies the presence of coronary artery disease and thereby appears to provide a more precise identification of cardiovascular risk than cardiovascular risk scoring. Specifically, coronary CT angiography identified individuals with coronary atheroma who would not have been identified as being at risk by 10-year cardiovascular risk scoring. More importantly, participants who had coronary atheroma identified were more likely to adopt a healthier lifestyle and to commence lipid-lowering therapies than those who were classified as at risk using a cardiovascular risk score. Knowledge of the presence of coronary atherosclerosis was also associated with greater improvements in car-

diovascular risk factors including cholesterol concentrations and blood pressure. Whether these differences will be sustained and translate into improved clinical outcomes remain to be established.

At 6 months, participant compliance with a healthy diet was greater in the CT angiography group, and more achieved a healthy body mass index. Although self-reported physical exercise was similar, participants randomized to coronary CT angiography had greater improvements in their daily step count compared with those randomized to standard care. Overall, only a modest proportion of participants achieved full compliance with NICE recommended targets for a healthy lifestyle: 1 in 6 individuals with CT angiography and 1 in 16 with cardiovascular risk scoring. This low level of compliance is consistent with previously reported studies[24,25] highlighting the challenges of sustaining healthy lifestyle behaviors. However, in those who underwent coronary CT angiography, we observed improved uptake of healthy lifestyle recommendations suggesting a greater willingness to achieve health gains.

The greater initiation of not only statins but also antiplatelet therapy and adoption of healthy lifestyle behaviors by those undergoing coronary CT angiography may be explained by a better appreciation of their cardiovascular risk and improved understanding of the rationale for treatment. Similar observations have also been made in other cardiovascular screening studies using cardiac CT, where individuals found to have atheroma were more likely to initiate statin therapy.[8,26,27] The presence of atherosclerosis is perhaps harder to dismiss than the presentation of potential risk. Applying the Health Belief Model, the presence of atherosclerosis helps individuals understand why they are at elevated risk, with the belief that subsequent changes in lifestyle and initiation of any preventive medications will minimize their future risk.[28] This perhaps explains the willingness of participants to initiate both antiplatelet and lipid-lowering therapy in those found to have atheroma by CT angiography, despite being recommended more therapy. It is also noteworthy that improvements in lifestyles were also seen in individuals with normal coronary arteries. Although we have yet to explore this fully, previous screening studies have noted similar findings, where those without carotid atheroma were motivated to preserve health and avoid future disease.[29]

In those undergoing CT angiography, we observed similar initiation of both statins and antiplatelet agents, with only 4% of those with atheroma not taking aspirin along with their statin. Clinical trials have failed to demonstrate overall benefit of antiplatelet therapy in primary prevention, with the reduction in atherothrombosis being negated by the risk of bleeding.[30-32] Whether the precision medicine approach of CT angiography could redress this balance remains to be seen, especially as observational data suggest that even in those with CT-defined atheroma, antiplatelet therapy does not reduce the future risk of cardiovascular events.[33] To address this, randomized clinical trial evidence must be generated, and this is a key outcome of the parent SCOT-HEART 2 trial.[14]

No differences in outcomes were observed between those who received a verbal report compared with those who visualized their CT images. Previous studies have reported mixed outcomes after visualization of cardiovascular imaging.[34] Perhaps, for the individuals within our study, visualization of detected plaque on CT at a single time point does not offer any further insights into their future risk over a verbal and written report alone. This may be due to the complexity of the images shown, the burden of information already provided, and an inability of the participants to refer back to their images.

Compared with cardiovascular risk scoring, we classified fewer individuals as at risk of future cardiovascular disease by CT angiography, which is consistent with other studies using cardiac CT to guide primary prevention.[8,35,36] In the Risk or Benefit in Screening for Cardiovascular Disease (ROBINSCA) trial, fewer individuals were classified as at risk by CT calcium scoring compared with cardiovascular risk scoring, resulting in fewer participants receiving a recommendation for preventive therapy.[35] In our study, over 1 in 4 individuals with a 10-year cardiovascular risk score greater than or equal to 10% would have received a recommendation for preventive therapy, even though they had normal coronary arteries by CT angiography. Although the possibility of undertreatment and future development of atherosclerosis must be considered, several studies have shown the absence of coronary atherosclerosis by CT angiography or coronary artery calcium scoring confer an exceptionally low risk of future myocardial infarction.[37-39] Interestingly, in those with normal coronary arteries in the CT Angiography Evaluation for Clinical Outcomes: An International Multicenter (CONFIRM) registry, no benefit from treatment with aspirin or statin was observed at 5 years.[38] In contrast, 1 in 5 individuals with a 10-year cardiovascular risk score less than 10% in our study had coronary atherosclerosis by coronary CT angiography and were recommended preventive therapy. In the St Francis Heart study, participants with atheroma by CT coronary artery calcium scoring were at risk of future cardiovascular events and derived benefit from statin therapy, even when their cardiovascular risk score was below treatment thresholds.[40]

In our previous trial of symptomatic patients with stable chest pain, we observed a 10% increase in the prescription of antiplatelet and statin therapy in those allocated to CT angiography and a 30% to 40% reduction in coronary heart disease death or nonfatal myocardial infarction, which was sustained at 10 years.[41,42] Some observers have suggested that such small differences in prescribing cannot account for the associated reductions in clinical events.[43] However, we have demonstrated here that CT angiography reclassified 1 in 3 participants and targeted primary prevention to those most likely to derive benefit. This reclassification, along with improved lifestyle changes and uptake of antiplatelet and statin therapy, may explain the previous improvements in clinical outcomes despite modest overall changes in preventive therapy. This is also consistent with the greater magnitude of fall in the 10-year cardiovascular risk score that we observed at 6 months (30%-40% reduction).

Limitations

Our study does have some important limitations. Half of the participants enrolled in the study had university-level education compared with the 26% average of the Scottish

population.[44] In addition, participants in the substudy may have represented a more or less motivated subgroup of individuals, and our effect sizes may be overestimated or underestimated compared with the wider SCOT-HEART 2 trial. Our follow-up period was limited to 6 months, and whether our findings will be sustained in the longer term is unknown. The current study was an open-label trial, and our primary end point was self-reported changes in diet, body mass index, smoking status, and physical exercise and may be prone to reporting bias. However, for all these domains except diet, we had objective measures of these variables as well as the associated cardiovascular risk factors. These independent objective measures demonstrated similar, if not greater, benefits, confirming the validity of our findings. Finally, the cost, radiation exposure, and resource implications may limit uptake of the use of coronary CT angiography in the screening of asymptomatic individuals for coronary atheroma.

Conclusions

In conclusion, results of this cohort study suggest that compared with cardiovascular risk scoring, those randomized to coronary CT angiography were less likely to receive a recommendation for lipid-lowering therapy, although they were more likely to accept recommended treatments and adopt healthier lifestyle behaviors. This was associated with improved risk factor optimization at 6 months, especially in those with coronary atheroma. It remains to be established whether these differences will translate into improved clinical outcomes.

ARTICLE INFORMATION

Accepted for Publication: March 21, 2025.

Published Online: June 18, 2025. doi:10.1001/jamacardio.2025.1763

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Obtained funding: Meah, Norrie, McKinstry, Guthrie, Mills, Dweck, Williams, Newby.
Administrative, technical, or material support: McDermott, Khaing, Meah, Wang, Craig, Loganath, van Beek, Ritchie, Newby.
Supervision: Khaing, Craig, van Beek, Ritchie, Mills, Dweck, Williams, Newby.

Conflict of Interest Disclosures: Dr van Beek reported being owner/founder of QCTIS Ltd; receiving consulting/speaker fees from AstraZeneca and Lunit; and receiving advisory board fees from DeepHealth/Aidence outside the submitted work. Dr Norrie reported being employed by the University of Edinburgh, which received grant funding from a noncommercial funder for the underlying research project. Dr McKinstry reported receiving grants from British Heart Foundation during the conduct of the study. Dr Guthrie reported receiving grants from British Heart Foundation Paid to institution to fund the study reported during the conduct of the study. Dr Kimenai reported receiving personal fees from Roche Diagnostics and grants from British Heart Foundation Basic Science Research Fellowship outside the submitted work. Dr Williams reported receiving consultant and/or speaker fees from Cannon Medical Systems, Siemens Healthineers, Novartis, and FEOPS outside the submitted work. Dr Newby reported receiving grants from British Heart Foundation during the conduct of the study. No other disclosures were reported.

Funding/Support: The British Heart Foundation funded the SCOT-HEART 2 IMPACT (grant FS/19/46/34445) and the main SCOT-HEART 2 (grant CS/18/4/34074) trials; Dr McDermott was supported by a clinical research training fellowship grant FS/CRTF/23/24491 from the British Heart Foundation; grants CH/09/002, CH/F/21/90010, FS/ICRF/20/26002, FS/SCRF/21/32010, RG/23/F/22/110093, RG/20/10/34966, and RE/24/130012 from the British Heart Foundation (Prof Mills, Dweck, Williams, and Newby); and the Edinburgh Imaging Facility and Edinburgh Clinical Research Facility are supported by the National Health Service Research Scotland (NRS) through National Health Service Lothian Health Board.

Role of the Funder/Sponsor: The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Data Sharing Statement: See Supplement 2.

Additional Information: Lay members of the public are members of the SCOT-HEART 2 Trial Steering Committee, and they were involved in the design and conduct of the trial. They were not involved in writing of the manuscript or interpretation of results.

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