ACCF/ACR/SCCT/SCMR/ASNC/NASCI/ SCAI/SIR Appropriateness Criteria for Cardiac Computed Tomography and Cardiac Magnetic Resonance Imaging – Online Appendix

A Report of the American College of Cardiology Foundation Quality Strategic Directions Committee Appropriateness Criteria Working Group, American College of Radiology, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, American Society of Nuclear Cardiology, North American Society for Cardiac Imaging, Society for Cardiovascular Angiography and Interventions, and Society of Interventional Radiology

CCT/CMR WRITING GROUP

Robert C. Hendel, MD, FACC, FAHA[*]
Manesh R. Patel, MD[*]
Christopher M. Kramer, MD, FACC, FAHA[‡] Michael Poon, MD, FACC[†]

Representative: [*]ACCF, [†]SCCT, [‡]SCMR

TECHNICAL PANEL MEMBERS

Robert C. Hendel, MD, FACC, FAHA, Moderator[**]
James C. Carr, MD, BCh, BAO[§§]
Nancy A. Gerstad, MD
Linda D. Gillam, MD, FACC, FAHA
John McB. Hodgson, MD, FSACI, FACC[‡‡]
Raymond J. Kim, MD, FACC
Christopher M. Kramer, MD, FACC, FAHA[‡]
John R. Lesser, MD, FACC
Edward T. Martin, MD, FACC, FACP, FAHA
Joseph V. Messer, MD, MACC, FAHA, FSCAI
Rita F. Redberg, MD, MSc, FACC[¶]
Geoffrey D. Rubin, MD, FSCBTMR[§]
John S. Rumsfeld, MD, PhD, FACC
Allen J. Taylor, MD, FACC, FAHA
Wm. Guy Weigold, MD, FACC[†]
Pamela K. Woodard, MD, FAHA[††]

Representative: [§]ACR, [¶]AHA, [**]ASNC, [††]NASCI, [‡‡]SCAI, [†]SCCT, [‡]SCMR, [§§]SIR

ACCF APPROPRIATENESS CRITERIA WORKING GROUP

Ralph G. Brindis, MD, MPH, FACC, Chair
Robert C. Hendel, MD, FACC, FAHA, Pamela S. Douglas, MD, MACC, FAHA
Eric D. Peterson MD, FACC, FAHA, Michael J. Wolk, MD, MACC,
Joseph M. Allen, MA, Manesh R. Patel, MD

APPENDIX A. CCT Appropriateness Criteria Ratings

	Indication	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Median	MADM	R	Agree	
Table 1. Detection of CAD: Symptomatic																					
Evaluation of Chest Pain Syndrome (Use of CT Angiogram)																					
1	▪ Intermediate pre-test probability ▪ ECG interpretable AND able to exercise	8	4	7	8	5	8	7	1	1	1	1	6	1	2	6	5	2.6	U		-
2	▪ Intermediate pre-test probability ▪ ECG uninterpretable OR unable to exercise	9	5	7	9	7	8	9	5	5	2	7	7	4	2	9	7	1.9	A		
3	▪ High pre-test probability of CAD	5	4	3	2	1	2	2	3	1	2	2	3	1	2	5	2	0.9	I	+	
Evaluation of Intra Cardiac Structures (Use of CT Angiogram)																					
4	▪ Evaluation of suspected coronary anomalies	9	9	9	9	9	9	9	8	9	7	8	8	7	7	9	9	0.6	A	+	
Acute Chest Pain (Use of CT Angiogram)																					
5	▪ Low pre-test probability of CAD ▪ No ECG changes and serial enzymes negative	6	4	9	9	6	5	7	1	5	2	2	6	1	2	6	5	2.1	U		
6	▪ Intermediate pre-test probability of CAD ▪ No ECG changes and serial enzymes negative	7	8	6	9	7	7	9	4	6	2	7	6	2	4	9	7	1.7	A		
7	▪ High pre-test probability of CAD ▪ No ECG changes and serial enzymes negative	6	3	6	1	2	8	5	4	7	7	6	6	1	1	9	6	2.1	U		
8	▪ High pre-test probability of CAD ▪ ECG – ST elevation and/or positive cardiac enzymes	1	4	2	1	1	1	1	1	1	2	1	2	1	1	1	1	0.4	I	+	
9	▪ "Triple rule out" – exclude obstructive CAD, aortic dissection, and pulmonary embolism ▪ Intermediate pre-test probability for one of the above ▪ ECG – no ST elevation and initial enzymes negative	5	2	8	5	2	6	8	1	7	6	4	3	1	2	4	4	2.0	U		

Indication	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Median	MADM	R	Agree	
Table 2: Detection of CAD: Asymptomatic (without Chest Pain Syndrome)																				
Asymptomatic (Use of CT Angiogram)																				
10	▪ Low CHD Risk (Framingham Risk Criteria)	2	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	0.2	I	+	
11	▪ Moderate CHD risk (Framingham)	5	3	2	1	1	5	4	1	1	1	4	3	1	1	3	2	1.3	I	+	
12	▪ High CHD risk (Framingham)	5	5	2	5	1	5	6	1	5	1	2	4	1	1	4	4	1.7	U		
Table 3. Risk Assessment: General Population																				
Asymptomatic (Calcium Scoring)																				
13	▪ Low CHD Risk (Framingham)	3	3	1	2	2	3	3	1	1	1	1	1	1	5	1	1	0.9	I	+	
14	▪ Moderate CHD Risk (Framingham)	8	8	6	8	7	6	8	3	5	1	7	5	1	8	3	6	2.0	U		
15	▪ High CHD Risk (Framingham)	7	5	7	2	2	7	9	1	6	1	5	6	1	5	4	5	2.1	U		
Table 4. Detection of CAD with Prior Test Results																				
Evaluation of Chest Pain Syndrome (Use of CT Angiogram)																				
16	▪ Uninterpretable or equivocal stress test (exercise, perfusion or stress echo)	8	7	9	9	8	9	8	8	7	7	7	7	3	5	9	8	1.1	A	+	
17	▪ Evidence of moderate to severe ischemia on stress test (exercise, perfusion or stress echo)	3	4	3	2	1	3	3	1	1	2	2	2	1	2	1	2	0.7	I	+	

Indication	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Median	MADM	R	Agree	
Table 5. Risk Assessment with Prior Test Results																				
Asymptomatic (Calcium Scoring)																				
18 ▪ Prior calcium score within previous 5 years	1	4	2	2	1	4	1	1	1	1	2	5	1	1	4	**1**	1.1	I	+	
Asymptomatic (Use of CT Angiogram)																				
19 ▪ High CHD Risk (Framingham) ▪ Within 2 years prior cardiac CT angiogram or invasive angiogram without significant obstructive disease	1	3	1	2	1	3	2	1	2	1	2	4	1	1	2	**2**	0.7	I	+	
20 ▪ High CHD Risk (Framingham) ▪ Prior calcium score greater than or equal to 400	1	4	1	3	1	5	4	1	5	4	4	4	1	1	2	**3**	1.5	I		

Indication	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Median	MADM	R	Agree	
Table 6. Risk Assessment: Preoperative Evaluation for Non-Cardiac Surgery																				
Low Risk Surgery (Use of CT Angiogram)																				
21	▪ Intermediate perioperative risk	3	2	2	2	1	3	1	1	2	1	1	2	1	1	1	1	0.6	I	+	
Intermediate or High Risk Surgery (Use of CT Angiogram)																				
22	▪ Intermediate perioperative risk	7	5	6	6	4	5	7	1	6	2	3	2	3	1	4	4	1.7	U		
Table 7. Detection of CAD: Post-Revascularization (PCI or CABG)																				
Evaluation of Chest Pain Syndrome (Use of CT Angiogram)																				
23	▪ Evaluation of bypass grafts and coronary anatomy	7	5	6	6	5	8	7	1	4	4	3	6	1	7	6	6	1.6	U		
24	▪ History of percutaneous revascularization with stents	7	5	6	6	2	7	7	1	5	4	3	6	1	1	3	5	1.9	U		
Asymptomatic (Use of CT Angiogram)																				
25	▪ Evaluation of bypass grafts and coronary anatomy ▪ Less than 5 years after CABG	3	3	2	2	2	3	2	1	2	1	2	2	1	1	2	2	0.5	I	+	
26	▪ Evaluation of bypass grafts and coronary anatomy ▪ Greater than or equal to 5 years after CABG	5	3	4	2	3	3	2	1	4	1	3	2	1	1	3	3	1.0	I	+	
27	▪ Evaluation for in-stent restenosis and coronary anatomy after PCI	6	3	2	2	2	3	2	1	2	1	3	2	1	1	2	2	0.7	I	+	

Indication	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Median	MADM	R	Agree	
Table 8. Structure and Function																				
Morphology (Use of CT Angiogram)																				
28	▪ Assessment of complex congenital heart disease including anomalies of coronary circulation, great vessels, and cardiac chambers and valves.	8	6	8	8	5	9	9	8	7	7	7	8	7	7	7	7	0.8	A	+	
29	▪ Evaluation of coronary arteries in patients with new onset heart failure to assess etiology	8	4	7	8	7	7	9	5	8	8	5	6	2	1	6	7	1.7	A		
Evaluation of Ventricular and Valvular Function																				
30	▪ Evaluation of LV function following myocardial infarction OR in heart failure patients	4	4	3	2	3	6	5	2	3	2	2	5	2	2	1	3	1.1	I		
31	▪ Evaluation of LV function following myocardial infarction OR in heart failure patients ▪ Patients with technically limited images from echocardiogram	7	4	6	5	4	8	8	4	4	4	6	6	1	4	5	5	1.4	U	+	
32	▪ Characterization of native and prosthetic cardiac valves ▪ Patients with technically limited images from echocardiogram, MRI or TEE	6	4	6	4	2	8	8	3	5	5	3	6	2	1	7	5	1.8	U		

	Indication	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Median	MADM	R	Agree	
Evaluation of Intra and Extra Cardiac Structures (Use of Cardiac CT)																					
33	▪ Evaluation of cardiac mass (suspected tumor or thrombus) ▪ Patients with technically limited images from echocardiogram, MRI or TEE	8	7	8	8	7	9	7	9	8	8	7	9	8	5	9	**8**	0.7	**A**	+	
34	▪ Evaluation of pericardial conditions (pericardial mass, constrictive pericarditis or complications of cardiac surgery) ▪ Patients with technically limited images from echocardiogram, MRI or TEE	8	8	9	7	7	9	6	9	8	9	8	9	8	7	9	**8**	0.7	**A**	+	
35	▪ Evaluation of pulmonary vein anatomy prior to invasive radiofrequency ablation for atrial fibrillation	9	9	9	8	9	9	8	7	9	8	8	9	8	5	8	**8**	0.7	**A**	+	
36	▪ Non-invasive coronary vein mapping prior to placement of bi-ventricular pacemaker	8	8	9	8	8	8	8	7	8	8	8	8	8	5	7	**8**	0.4	**A**	+	
37	▪ Non-invasive coronary arterial mapping, including internal mammary artery prior to repeat cardiac surgical revascularization	9	8	7	8	9	9	8	7	3	8	7	8	2	5	3	**8**	1.7	**A**	+	
Evaluation of Aortic and Pulmonary Disease (Use of CT Angiogram*)																					
38	▪ Evaluation of suspected aortic dissection or thoracic aortic aneurysm	9	8	9	9	9	9	9	9	9	8	9	9	9	8	9	**9**	0.2	**A**	+	
39	▪ Evaluation of suspected pulmonary embolism	9	9	9	9	9	9	9	9	9	8	9	9	9	8	9	**9**	0.1	**A**	+	

* Non-gated, CT angiogram which has a sufficiently large field of view for these specific indications

- Median is middle most rating.
- MADM is mean absolute deviation from median.
- “I” is inappropriate; “U” is uncertain, and “A” is appropriate; “+” is agreement and “-” is disagreement. Level of agreement was based on BIOMED rule for a panel of 14-16 (i.e., agreement is where 4 or less panelists rate outside the 3-point region containing the median indicates agreement and disagreement is where the number of panelists rating in each extreme region is at least 5).

Appendix B. CMR Appropriateness Criteria Ratings

	Indication	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Median	MADM	R	Agree	
Table 1. Detection of CAD: Symptomatic																					
Evaluation of Chest Pain Syndrome (Use of Vasodilator Perfusion CMR or Dobutamine Stress Function CMR)																					
1	▪ Low pre-test probability of CAD ▪ ECG interpretable AND able to exercise	3	4	3	2	2	3	2	1	1	1	1	1	1	2	4	2	0.9	I	+	
2	▪ Intermediate pre-test probability of CAD ▪ ECG interpretable AND able to exercise	6	5	4	4	4	3	2	4	3	1	2	4	1	4	8	4	1.3	U		
3	▪ Intermediate pre-test probability of CAD ▪ ECG uninterpretable OR unable to exercise	8	8	8	8	9	6	5	8	6	7	4	6	4	5	9	7	1.3	A		
4	▪ High pre-test probability of CAD	8	6	5	2	6	3	5	5	3	3	2	6	1	2	9	5	1.7	U		
Evaluation of Chest Pain Syndrome (Use of MR Coronary Angiography)																					
5	▪ Intermediate pre-test probability of CAD ▪ ECG interpretable AND able to exercise	1	2	2	2	2	3	2	2	1	1	1	1	1	2	1	2	0.5	I	+	
6	▪ Intermediate pre-test probability of CAD ▪ ECG uninterpretable OR unable to exercise	1	4	2	2	3	3	4	5	3	3	2	2	1	2	2	2	0.9	I	+	
7	▪ High pre-test probability of CAD	1	2	2	1	1	3	1	3	1	1	1	1	1	2	1	1	0.4	I	+	
Evaluation of Intra Cardiac Structures (Use of MR Coronary Angiography)																					
8	▪ Evaluation of suspected coronary anomalies	9	9	9	8	8	9	8	9	8	8	8	4	7	6	7	8	0.7	A	+	

Acute Chest Pain (Use of Vasodilator Perfusion CMR or Dobutamine Stress Function CMR)																					
9	▪ Intermediate pre-test probability of CAD ▪ No ECG changes and serial enzymes negative	7	7	4	6	8	5	7	8	4	6	6	4	2	7	9	**6**	1.4	**U**		
10	▪ High pre-test probability of CAD ▪ ECG –ST elevation and/or positive cardiac enzymes	1	2	1	1	2	3	1	1	1	1	1	2	1	1	1	**1**	0.3	**I**	+	
Table 2. Risk Assessment with Prior Test Results (Use of Vasodilator Perfusion CMR or Dobutamine Stress Function CMR)																					
11	▪ Normal prior stress test (exercise, nuclear, echo, MRI) ▪ High CHD Risk (Framingham) ▪ Within 1 year of prior stress test	2	3	1	1	2	3	2	1	1	1	2	2	1	1	5	**2**	0.7	**I**	+	
12	▪ Equivocal stress test (exercise, nuclear, or stress echo) ▪ Intermediate CHD Risk (Framingham)	8	9	7	6	8	6	8	8	6	6	6	6	3	5	9	**6**	1.2	**U**		
13	▪ Coronary angiography (catheterization or CT) ▪ Stenosis of unclear significance	9	8	6	7	8	6	8	8	6	6	6	6	1	7	9	**7**	1.3	**A**		
Table 3. Risk Assessment: Preoperative Evaluation for Non-Cardiac Surgery																					
Low Risk Surgery (Use of Vasodilator Perfusion CMR or Dobutamine Stress Function CMR)																					
14	▪ Intermediate perioperative risk predictor	2	3	2	2	1	2	2	1	3	1	2	2	1	1	3	**2**	0.5	**I**	+	
Intermediate or High Risk Surgery (Use of Vasodilator Perfusion CMR or Dobutamine Stress Function CMR)																					
15	▪ Intermediate perioperative risk predictor	7	6	5	6	8	5	8	6	6	2	6	5	3	6	9	**6**	1.2	**U**		
Table 4. Detection of CAD: Post-Revascularization (PCI or CABG)																					
Evaluation of Chest Pain Syndrome (Use of MR Coronary Angiography)																					
16	▪ Evaluation of bypass grafts	2	6	4	2	4	6	2	1	2	1	2	1	1	4	5	**2**	1.3	**I**		
17	▪ History of percutaneous revascularization with stents	2	3	1	1	1	1	1	1	1	5	1	1	1	3	1	**1**	0.5	**I**	+	

Table 5. Structure and Function																					
Evaluation of Ventricular and Valvular Function																					
Procedures may include LV / RV mass and volumes, MR Angiography, quantification of valvular disease, and delayed contrast enhancement																					
18	▪ Assessment of complex congenital heart disease including anomalies of coronary circulation, great vessels, and cardiac chambers and valves. ▪ Procedures may include LV / RV mass and volumes, MR Angiography, quantification of valvular disease, and contrast enhancement	9	9	9	9	9	9	9	9	8	8	9	8	8	8	9	**9**	0.3	**A**	+	
19	▪ Evaluation of LV function following myocardial infarction OR in heart failure patients	8	8	5	5	9	9	7	4	6	6	4	9	2	6	9	**6**	1.8	**U**		
20	▪ Evaluation of LV function following myocardial infarction OR in heart failure patients ▪ Patients with technically limited images from echocardiogram	9	9	8	8	9	9	8	7	8	8	6	9	7	8	9	**8**	0.7	**A**	+	
21	▪ Quantification of LV function ▪ Discordant information that is clinically significant from prior tests	8	9	9	8	9	9	9	8	8	8	7	9	1	7	9	**8**	1.0	**A**	+	
22	▪ Evaluation for specific cardiomyopathies (heart failure of uncertain etiology) [infiltrative (amyloid, sarcoid), HCM, or due to cardiotoxic therapies] ▪ Use of delayed enhancement	9	8	9	8	9	9	8	9	9	8	8	8	7	7	9	**8**	0.5	**A**	+	
23	▪ Characterization of native and prosthetic cardiac valves – including planimetry of stenotic disease and quantification of regurgitant disease ▪ Patients with technically limited images from echocardiogram or TEE	8	7	9	8	8	8	8	7	7	8	6	5	7	6	9	**8**	0.7	**A**	+	

24	▪ Evaluation for arrythmogenic right ventricular cardiomyopathy (ARVC) ▪ Patients presenting with syncope or ventricular arrythmia	9	9	9	8	9	8	9	9	8	8	9	8	3	6	9	**9**	0.7	**A**	+	
25	▪ Evaluation of myocarditis or myocardial infarction with normal coronary arteries ▪ Positive cardiac enzymes without obstructive atherosclerosis on angiography	9	8	9	8	9	9	8	7	9	8	8	8	3	6	9	**8**	0.8	**A**	+	
Evaluation of Intra and Extra Cardiac Structures																						
26	▪ Evaluation of cardiac mass (suspected tumor or thrombus) ▪ Use of contrast for perfusion and enhancement	9	9	9	8	9	9	9	9	9	8	9	9	8	8	9	**9**	0.2	**A**	+	
27	▪ Evaluation of pericardial conditions (pericardial mass, constrictive pericarditis)	9	8	9	8	9	9	9	8	8	8	8	9	8	7	9	**8**	0.5	**A**	+	
28	▪ Evaluation for aortic dissection	9	9	8	8	8	9	9	8	8	8	8	8	8	8	9	**8**	0.3	**A**	+	
29	▪ Evaluation of pulmonary veins prior to radiofrequency ablation for atrial fibrillation ▪ Left atrial and pulmonary venous anatomy including dimensions of veins for mapping purposes	9	8	8	8	9	9	8	7	8	8	9	7	8	6	9	**8**	0.5	**A**	+	

Table 6. Detection of Myocardial Scar and Viability																						
30	▪ To determine the location, and extent of myocardial necrosis including 'no reflow' regions ▪ Post acute myocardial infarction	9	7	9	8	8	9	6	1	7	7	4	8	1	2	9	**7**	1.8	**A**		
31	▪ To detect post PCI myocardial necrosis	5	6	5	2	4	9	1	1	7	8	3	7	1	2	4	**4**	2.1	**U**		
32	▪ To determine viability prior to revascularization ▪ Establish likelihood of recovery of function with revascularization (PCI or CABG) or medical therapy	9	8	9	8	9	9	8	9	9	8	9	7	7	6	9	**9**	0.5	**A**	+	
33	▪ To determine viability prior to revascularization ▪ Viability assessment by SPECT or Dobutamine Echo has provided "equivocal or indeterminate" results	8	8	9	9	9	9	9	9	9	9	9	8	7	7	9	**9**	0.3	**A**	+	

- Median is middle most rating.
- MADM is mean absolute deviation from median.
- "I" is inappropriate; "U" is uncertain, and "A" is appropriate; "+" is agreement and "-" is disagreement. Level of agreement was based on BIOMED rule for a panel of 14-16 (i.e., agreement is where 4 or less panelists rate outside the 3-point region containing the median indicates agreement and disagreement is where the number of panelists rating in each extreme region is at least 5).

Appendix C. CCT Evidence Summary and Tables

The sensitivity of advanced MDCT technology with a slice collimation less than 1.0 mm for the detection of hemodynamically significant coronary artery stenosis has been demonstrated to be very high (i.e. higher than 95% in most of all currently available published reports using 16 or more detector row CTs) provided that image quality is adequate, evaluation is performed by CCT experts, and the patients are properly chosen and prepared prior to the study.

CCT has been used for the diagnosis of hemodynamically significant coronary artery disease in patients with a low to intermediate likelihood of having significant stenosis (Tables 1 and 2[*]).

CCT also has been used to facilitate a decision for or against invasive coronary angiography in patients who had an uninterpretable or equivocal stress ECG or stress myocardial perfusion study.

CCT has been used for the assessment of coronary anomalies, pulmonary veins and left atrium prior to radiofrequency ablation of atrial fibrillation, and coronary vein mapping prior to the placement of pacemaker leads for cardiac resynchronization therapy.

The use of CCT for stent occlusion and patency as well as bypass graft patency continues to be under investigation (Tables 3 and 4).

CT imaging has been used to detect and rule out aortic dissection and pulmonary embolism.

[*] Publication Note: Studies cited in Tables 1 and 2 generally can be inferred to be of patients at intermediate risk of disease. The sensitivity and specificity data cited are primarily for studies in which patients had a high prevalence of disease.

TABLE1: Sensitivities and Specificities of 16-slice CT and 64-slice for the detection of coronary artery stenoses

	N	Rotation	Sens.	Spec.	NPV	unevaluable	Comments
16-SLICE CT							
Nieman[13]	59	420 ms	95%	86%	97%	7%	*Per-artery analysis, all segments > 2.0 mm*
Ropers [14]	77	420 ms	93%	92%	97%	12%	*Per-artery analysis, all segments > 1.5 mm*
Kuettner [15]	58	420 ms	72%	97%	97%	--	*Per-segment analysis, all segments*
			98%	98%	100%	--	*Analysis in all patients with Agatston Score < 1000*
Mollet [16]	128	420 ms	92%	95%	98%	--	*Per-segment analysis, all segments > 2.0 mm*
Martuscelli [17]	64	500 ms	89%	98%	98%	16%	*Per-artery analysis, all segments > 1.5mm*
Fine [18]	50	420 ms	87%	97%	98%	2%	*Per-artery analysis, all segments > 1.5mm*
Kaiser [19]	149	420 ms	30%	91%	83%	23%	*Per-artery analysis, all segments*
Aviram[20]	22	420 ms	86%	98%	98%	--	*Per-segment analysis, all segments > 1.5 mm*
Hoffmann [21]	33	420 ms	63%	96%	96%	--	*Per-segment analysis, all segments*
	33	420 ms	89%	95%	97%	--	*Per-segment analysis, prox. and mid segments*
Kuettner [22]	124	375 ms	85%	98%	96%	7%	*Per-segment analysis all segments*
Mollet [23]	51	375 ms	95%	98%	99%	--	*Per-artery analysis, all segments > 2.0 mm*
Morgan-Hughes [24]	58	500 ms	83%	97%	97%	2%	*Per-segment analysis, All segments*
			89%	*98%*	*98%*	-	*Analysis in all 36 patients with an Agatston Score <400*

Schujif [25]	45	420 ms	98%	97%	100%	6%	*Per-segment analysis, all segments**
Hoffmann [26]	103	420 ms	95%	98%	99%	6%	*Per-segment analysis All segments ≥ 1.5 mm*
Achenbach [27]	50	375 ms	94%	96%	99%	4%	*Per-segment analysis, all segments > 1.5 mm*
64-SLICE CT							
Leschka [28]	53	370 ms	94%	97%	99%	-	*Per-segment analysis, all segments**
Raff [29]	70	*330 ms*	*86%*	95%	98%	*12%*	*Per-segment analysis*
Leber [30]	59	330 ms	73% *all segments*	97%	99%	-	*Per segment analysis,*
			88%	97%	99%	-	*Per segment analysis mid and proximal segments*
Mollet [31]	52	330 ms	99%	95%	99%	2%	*Per segment analysis, all segments*
Ropers [32]	82	330 ms	95%	93%	99%	4%	*Per artery analysis, all segments > 1.5 mm*
Fine [33]	66	330 ms	95%	96%	95%	6%	*Per artery analysis, All arteries > 1,5 mm*

**this study includes some patients with bypass grafts and stents which were not included in this evaluation*

Table 2: Per-patient analysis regarding detection of patients with at least one significant coronary artery stenosis in studies performed by 16-slice and 64-slice CT.

	N	Collimation/ Rotation	Sensitivity	Specificity	Pos.Pred.Value	Neg.Pred.Value
Nieman [13]	59	12x0,75/420ms	100%	88%	98%	100%
Ropers [14]	77	12x0,75/420ms	85%	78%	81%	82%
Mollet [16]	128	12x0,75/420ms	100%	86%	97%	100%
Kaiser [19]	149	12x0,75/420ms	86%	49%	84%	53%
Aviram [20]	22	16x0.75/420ms	100%	--	--	--
Hoffmann [21]	33	12x0.75/420ms	86%	82%	90%	75%
Mollet [23]	51	16x0.75/375ms	100%	100%	100%	100%
Hoffmann [26]	103	16x0,75/420ms	95%	97%	98%	94%
Achenbach [27]	50	16x0.75/375ms	100%	83%	86%	100%
Leschka [28]	53	64x0.6/375ms	100%	100%	100%	100%
Raff [29]	70	64x0,6/330ms	*95%*	*90%*	*93%*	*93%*
Leber [30]	59	64x0,6/330ms	94%	--	--	--
Mollet [31]	52	64x0,6/330ms	100%	92%	97%	100%
Ropers [32]	82	64x0,6/330ms	96%	91%	83%	98%

Table 3: Assessment of Coronary Stents by 16- and 64-slice CT
* number of stents
** sensitivity and specificity in evaluable stents

	N*	CT	Sens**	Spec.**	unevaluable	Comments
Schuijf [36]	65	16-slice	78%	100%	23%	
Kitagawa [37]	42	16-slice	100%		31%	
Gilard [35]	232	16-slice	54% 86%	100% 100%	49% 18%	*Stents <= 3 mm* *Stents > 3mm*
Gilard [39]	29	16-slice	100%		7%	*Left main stents only (mean dianeter 3.9 mm)*
Gaspar [38]	111	40-slice	72%	92%	--	*mean stent diameter 3.3mm*
Cademartiti [40]	51	64-slice	83%	99%		

Table 4: Detection of Bypass Graft Occlusion and Stenosis by 16-slice MDCT

		Bypass Occlusion			Bypass Stenosis		
	N (Patients)	**Sens.**	**Spec.**	**n.e.***	**Sens.**	**Spec.**	**n.e.***
Nieman [41]	24	100%	98%	0-5%	60-83%	88-90%	5-10%
Martuscelli [42]	96	100%	100%	9-12%	90%	100%	9-12%
Schlosser [43]	51	100%	100%	12%	90%	100%	12%
Chiurlia [44]	51	100%	100%	0%	96%	100%	0%
Moore [45]	50	100%	100%	0%	100%	99%	0%
Burgstahler [46]	13	100%	100%	5%	100%	93%	0%
Salm [47]	25	100%	100%	8%	100%	94%	8%

* Not evaluable

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Appendix D. Cardiac MRI (CMR) Evidence Summary

Cardiovascular MRI (CMR) utilizes magnetic resonance imaging with or without contrast infusion (gadolinium based agents) to provide detailed analysis of cardiac and vascular structure and function when performed by experienced operators/readers(1) in patients without contraindications. The Society for Cardiovascular Magnetic Resonance Imaging (SCMR) has published clinical indications for CMR.(2) CMR in patients with pacemakers and implantable cardioverter defibrillators requires careful consideration of potential risks and benefits. Patients with intracoronary stents are safe to image even immediately after placement. Gadolinium based contrast agents have an excellent side effect profile. In contrast to iodinated contrast media, they are not nephrotoxic and the incidence of serious allergic reactions is less than 0.01%

CMR offers detailed evaluation of cardiac anatomy.

- This includes evaluation of congenital heart disease in both children and adults with congenital heart disease including post surgical follow up. CMR provides a radiation free method for assessing overall structure and great vessel anatomy, evaluating the right ventricle, quantifying valvular regurgitation and shunts, and identifying areas of fibrosis with contrast enhancement.(3-9)
- CMR has been studied in patients with valvular disease and compared to invasive(10) and echocardiographic assessment(11).
- CMR has been used to identify a cardiac mass concerning for tumor, and may help differentiate ventricular thrombus.(12)
- CMR also has been used for evaluation of patients with specific cardiomyopathies, specifically non-ischemic cardiomyopathies such as infiltrative cardiomyopathies [sarcoid(13,14), amyloid(15)], hypertrophic cardiomyopathy(16-18), cardiomyopathies dues to iron overload or other cardiotoxins(19-24), arrythmogenic right ventricular cardiomyopathy (ARVC)(25-29), myocarditis(30-33), and several rarer forms of cardiomyopathy(34-39).
- CMR also has been used in extra-cardiac evaluation of structures such as the pericardium (i.e. constriction)(40), aortic diseases(41), and pulmonary veins prior to ablation.(42,43)

For patients in whom repeated measurements of ventricular parameters are required, CMR has been noted to have a higher inter-study reproducibility for left and right ventricular volumes, ejection fraction, and mass in patients with normal, dilated, and hypertrophied hearts.(44,45)

CMR has been used for infarct detection and viability.

- Delayed enhancement with gadolinium contrast CMR (DE-CMR) has been shown to be a reproducible technique(46) with high resolution for detecting minute amounts of myocardial damage following infarction.(47,48), and is more sensitive than SPECT for detecting subendocardial infarcts.(49) In acute infarcts, DE-CMR

identifies the transmural extent of infarction and predicts long-term contractile improvement(50).

- Therefore, CMR has been used as a test of myocardial viability to identify patients that will respond to coronary revascularization(51-53) and medical therapy such as beta-blockers.(54,55)
- CMR also has been used to identify areas of infarction following percutaneous intervention and bypass surgery.(56-59)

Dobutamine stress CMR has been used to diagnose CAD and establish prognosis, especially in patients not suitable for stress echocardiography.(60-62)

Detection of CAD with perfusion remains a technically evolving field. In general, stress perfusion CMR has been used to diagnose hemodynamically significant coronary artery disease in patients with intermediate to high likelihood of having significant stenosis. Numerous studies have been performed evaluating the diagnostic accuracy of stress perfusion CMR(63-69), including recent multi-center dose ranging studies.(70,71) (See Table 1 – Stress CMR)

MRA of coronary arteries has been used for identifying anomalous coronary arteries(72). The techniques remain in development. Varying sensitivity, specificity, and accuracy have been noted in studies using existing techniques.(73) (Table 2 - MR detection of coronary artery stenoses).

In patients with acute chest pain in the emergency room, the combination approach of cine, rest perfusion, and delayed enhancement CMR has been used in the diagnosis of acute coronary syndromes(67) and for patients with NSTEMI(74).

CMR has been used for the evaluation of bypass graft and stent occlusion and patency(75). The visualization of coronary stent lumen is influenced substantially both by scanner technology as well as size and type of stent.

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