1. Summary of Guideline

Table 1. Detection of CAD

Indication		Level of Evi-dence	Appropri-ateness Criteria (score)	References
Detection of CAD: Symptomatic				
1. Evaluation of Chest Pain Syndrome *(Protocols may include vasodilator perfusion CMR, dobutamine stress function CMR, and/or MR coronary angiography)*				
Q1	Low pre-test probability of CAD/ECG interpretable AND able to exercise	A	I(2)	(13, 34, 39, 65)
Q2	Intermediate pre-test probability of CAD/ECG interpretable AND able to exercise	A	U(4)	(13, 34, 39, 65)
Q3	Intermediate pre-test probability of CAD/ECG uninterpretable OR unable to exercise	A	A(7)	(13, 34, 39, 65)
Q4	High pre-test probability of CAD	A	U(6)	(13, 34, 39, 65)
2. Evaluation of Intracardiac Structures *(Use of MR Coronary Angiography)*				
Q5	Evaluation of suspected coronary anomalies	B	A(8)	(46, 47)
3. Acute Chest Pain *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
Q6	Low pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	A	U(4)	(48, 51, 52)
Q7	Intermediate pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	A	U(5)	(48, 51)
Q8	High pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	A	U(5)	(48, 51)
Q9	High pre-test probability of CAD/ECG—ST-segment elevation and/or positive cardiac enzymes	A	I(2)	(48, 51)
4. Detection of CAD: with Prior Test Results *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
Q10	Normal prior stress test (exercise, nuclear, echo, MRI)/High CHD risk (Framingham)/Within 1 year of prior stress test	A	I(2)	(13, 17, 65)
Q11	Equivocal stress test (exercise, stress SPECT, or stress echo)/Intermediate CHD risk (Framingham)	A	U(6)	(13, 17, 65)
Q12	Coronary angiography (catheterization or CT)/Stenosis of un-	C	A(7)	(64)

	clear significance			
5. Evaluation of CAD: Post PCI or CABG				
Evaluation of Chest Pain Syndrome (Use of MR Coronary Angiography)				
Q13	Evaluation of bypass grafts	C	U(4)	(69, 70)
Q14	History of percutaneous revascularization with stent	C	I(3)	(71, 72)
Asymptomatic (Use of MR Coronary Angiography)				
Q15	Evaluation of bypass grafts and coronary anatomy	C	I(3)	(69, 70)
Q16	Evaluation for in-stent restenosis and coronary anatomy after PCI	C	I(3)	(71, 72)
6. CAD Risk Assessment: Preoperative Evaluation *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
Q17	Low-risk non-cardiac surgery in patients with intermediate perioperative risk predictors	C	I(3)	(82)
Q18	Intermediate or high risk non-cardiac surgery in patients with intermediate perioperative risk predictors	C	U(5)	(82)
Q19	CAD evaluation before valve surgery	C	U(6)	(82)
7. Evaluation of CAD: In Pediatric Patients with Kawasaki Disease *(Use of MR Coronary Angiography)*				
Asymptomatic				
Q20	No previous definitive test (catheter-based XCA, MR coronary angiography, or CT coronary angiography) available	B	U(5)	(84, 85, 87)
Q21	Previous tests (catheter-based XCA, MR coronary angiography, or CT coronary angiography) documented coronary aneurysm/stenosis, for follow up	B	A(7)	(84, 85, 87)
Symptomatic				
Q22	No previous definitive test (catheter-based XCA, MR coronary angiography, or CT coronary angiography) available	B	A(7)	(84, 85, 87)
Q23	Previous tests (catheter-based XCA, MR coronary angiography, or CT coronary angiography) documented coronary aneurysm/stenosis, for follow up	B	A(7)	(84, 85, 87)
8. Detection of CAD: Asymptomatic *(Protocols may include vasodilator perfusion CMR, dobutamine stress function CMR, and/or MR coronary angiography)*				
Q24	Low CHD risk (Framingham)	A	I(1)	(89)
Q25	Moderate CHD risk (Framingham)	A	U(4)	(89)
Q26	High CHD risk (Framingham)	A	U(6)	(89)

9. Detection of Myocardial Scar and Viability in Ischemic Heart Disease *(Protocols may include LGE evaluation or dobutamine stress function CMR)*				
Q27	To determine the location and extent of myocardial necrosis including 'no reflow' regions/Post-acute myocardial infarction	A	A(9)	(92-94)
Q28	To detect post PCI myocardial necrosis	A	A(8)	(95, 101)
Q29	To determine viability prior to revascularization/Establish likelihood of recovery of function with revascularization (PCI or CABG) or medical therapy	A	A(9)	(96, 101, 102)
Q30	To determine viability prior to revascularization/Viability assessment by SPECT or dobutamine echo has provided "equivocal or indeterminate" results	A	A(9)	(13, 97, 98)

Table 2. Structure and Myocardial Functional Evaluation in Patients with Risk of Heart Failure or Overt Heart Failure

Indication		Level of Evidence	Appropriateness Criteria (score)	References
10. Evaluation in Patients with Risk of Heart Failure or Overt Heart Failure (General) *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*				
Q31	Evaluation of LV function following myocardial infarction OR in heart failure patients	A	A(7)	(116, 121, 131)
Q32	Evaluation of LV function following myocardial infarction OR in heart failure patients/Patients with technically limited images from echocardiogram	A	A(9)	(108, 115, 116)
Q33	Quantification of LV function/Discordant information that is clinically significant from prior tests	A	A(9)	(108, 115, 116)
Q34	Evaluation in patients with new onset heart failure to assess etiology	A	A(8)	(119-121)
Q35	Initial evaluation of structure and function for newly suspected or potential heart failure (also including malignancy on current or planned cardiotoxic therapy and no prior imaging evaluation/familial or genetic cardiomyopathy in first-degree relative, known adult congenital heart disease, acute myocardial infarction during initial hospitalization)	A	A(8)	(119, 120, 124)
Q36	Evaluation determine patient candidacy of ICD therapy (ejec-	A	A(8)	(132-134)

	tion fraction and/or other structural information)			
Q37	Initial evaluation determine patient candidacy of CRT or procedural planning (ejection fraction, fibrosis, scarring, coronary vein variation, and intra-cavitary thrombus)	A	A(8)	(135, 136)
Q38	Cardiac function follow up after ICD or CRT	C	I(3)	(138, 139)
11. In Congenital Heart Disease *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*				
Q39	Assessment of complex congenital heart disease including anomalies of coronary circulation, great vessels, and cardiac chambers and valves	A	A(8)	(45, 144, 153, 154)
Q40	Assessment of post-operative congenital heart disease including ventricular and valvular function and anatomy evaluation	A	A(8)	(163, 166, 168)
12. In Valvular Heart Disease *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*				
Q41	Characterization of native and prosthetic cardiac valves—including planimetry of stenotic disease and quantification of regurgitant disease/Patients with technically limited images from transthoracic or transesophageal echocardiography	A	A(8)	(175, 187)
13. In Suspected or Diagnosed Myocardial Disease (*Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*				
Q42	Evaluation for ARVD/C patients presenting with syncope or ventricular arrhythmia	A	A(9)	(189-191)
Q43	Evaluation of myocarditis or myocardial infarction with normal coronary arteries/Positive cardiac enzymes without obstructive atherosclerosis on angiography	A	A(9)	(129, 202, 203)
Q44	Evaluation of specific cardiomyopathies (infiltrative [amyloid, sarcoid, etc.] or due to cardiotoxic therapies)	A	A(9)	(124, 192, 209)
14. Evaluation in HCM				
Q45	In HCM patients with inconclusive or inadequate echocardiography	A	A(9)	(205, 207, 208, 215)
Q46	To define apical hypertrophy and/or aneurysm if echocardiography is inconclusive	A	A(9)	(205, 207, 208, 215)
Q47	In selected patients with known HCM, when SCD risk stratifi-	A	A(8)	(126, 221)

	cation is inconclusive after documentation of the conventional risk factors/Use of LGE evaluation			

Table 3. Miscellaneous

Indication		Level of Evidence	Appropriateness Criteria (score)	References
Q48	**15. Evaluation of Cardiac Mass (Suspected Tumor or Thrombus)**/*Use of Contrast for Perfusion and Enhancement*	A	A(9)	(231-234)
Q49	**16. Evaluation of Pericardium (Pericardial Mass, Constrictive Pericarditis)**	B	A(8)	(236, 237, 239)
Q50	**17. Evaluation for Aortic Dissection**	A	A(8)	(240)
Q51	**18. Evaluation of Pulmonary Veins Prior to Radiofrequency Ablation for Atrial Fibrillation/**Left Atrial and Pulmonary Venous Anatomy Including Dimensions of Veins for Mapping Purposes	B	A(7)	(241-243)
Q52	**19. Anatomic Assessment Before Percutaneous Device Closure of ASD or VSD/**Anatomic Assessment Before Percutaneous Device Closure of ASD or VSD/Anatomic Assessment Before Percutaneous Device Closure or Percutaneous Aortic Valve Replacement	B	A(7)	(244, 245, 247)

2. CMR Appropriateness Criteria (By Appropriateness Category)

Table 1. Appropriateness Indications (Median score 7-9)

	Indication	Level of Evi-dence	Appro-priate-ness Criteria (score)	References
Detection of CAD: Symptomatic				
1. Evaluation of Chest Pain Syndrome *(Protocols may include vasodilator perfusion CMR, dobutamine stress function CMR, and/or MR coronary angiography)*				
Q3	Intermediate pre-test probability of CAD/ECG uninterpretable OR unable to exercise	A	A(7)	(13, 34, 39, 65)
2. Evaluation of Intracardiac Structures *(Use of MR Coronary Angiography)*				
Q5	Evaluation of suspected coronary anomalies	B	A(8)	(46, 47)
4. Detection of CAD: with Prior Test Results *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
Q12	Coronary angiography (catheterization or CT)/Stenosis of un-clear significance	C	A(7)	(64)
7. Evaluation of CAD: in Pediatric Patients with Kawasaki Disease *(Use of MR Coronary Angiography)*				
Asymptomatic				
Q21	Previous tests (catheter-based XCA, MR coronary angiography, or CT coronary angiography) documented coronary aneu-rysm/stenosis, for follow up	B	A(7)	(84, 85, 87)
Symptomatic				
Q22	No previous definitive test (catheter-based XCA, MR coronary angiography, or CT coronary angiography) available	B	A(7)	(84, 85, 87)
Q23	Previous tests (catheter-based XCA, MR coronary angiography, or CT coronary angiography) documented coronary aneu-rysm/stenosis, for follow up	B	A(7)	(84, 85, 87)
9. Detection of Myocardial Scar and Viability in Ischemic Heart Disease *(Protocols may include LGE evaluation or dobutamine stress function CMR)*				
Q27	To determine the location and extent of myocardial necrosis including 'no reflow' regions/Post-acute myocardial infarction	A	A(9)	(92-94)
Q28	To detect post PCI myocardial necrosis	A	A(8)	(95, 101)
Q29	To determine viability prior to revascularization/Establish likeli-	A	A(9)	(96, 101, 102)

	hood of recovery of function with revascularization (PCI or CABG) or medical therapy			
Q30	To determine viability prior to revascularization/Viability assessment by SPECT or dobutamine echo has provided "equivocal or indeterminate" results	A	A(9)	(13, 97, 98)
10. Evaluation in Patients with Risk of Heart Failure or Overt Heart Failure (General) *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*				
Q31	Evaluation of LV function following myocardial infarction OR in heart failure patients	A	A(7)	(116, 121, 131)
Q32	Evaluation of LV function following myocardial infarction OR in heart failure patients/Patients with technically limited images from echocardiogram	A	A(9)	(108, 115, 116)
Q33	Quantification of LV function/Discordant information that is clinically significant from prior tests	A	A(9)	(108, 115, 116)
Q34	Evaluation in patients with new onset heart failure to assess etiology	A	A(8)	(119-121)
Q35	Initial evaluation of structure and function for newly suspected or potential heart failure (also including malignancy on current or planned cardiotoxic therapy and no prior imaging evaluation/familial or genetic cardiomyopathy in first-degree relative, known adult congenital heart disease, AMI during initial hospitalization)	A	A(8)	(119, 120, 124)
Q36	Evaluation determine patient candidacy of ICD therapy (ejection fraction and/or other structural information)	A	A(8)	(132-134)
Q37	Initial evaluation determine patient candidacy of CRT or procedural planning (ejection fraction, fibrosis, scarring, coronary vein variation, and intra-cavitary thrombus)	A	A(8)	(135, 136)
11. In Congenital Heart Disease *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*				
Q39	Assessment of complex congenital heart disease including anomalies of coronary circulation, great vessels, and cardiac chambers and valves	A	A(8)	(45, 144, 153, 154)
Q40	Assessment of post-operative congenital heart disease including ventricular and valvular function and anatomy evaluation	A	A(8)	(163, 166, 168)
12. In Valvular Heart Disease				

(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)				
Q41	Characterization of native and prosthetic cardiac valves—including planimetry of stenotic disease and quantification of regurgitant disease/Patients with technically limited images from transthoracic or transesophageal echocardiography	A	A(8)	(175, 187)
13. In Suspected or Diagnosed Myocardial Disease (*Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*				
Q42	Evaluation for ARVD/C patients presenting with syncope or ventricular arrhythmia	A	A(9)	(189-191)
Q43	Evaluation of myocarditis or myocardial infarction with normal coronary arteries/Positive cardiac enzymes without obstructive atherosclerosis on angiography	A	A(9)	(129, 202, 203)
Q44	Evaluation of specific cardiomyopathies (infiltrative [amyloid, sarcoid, etc.] or due to cardiotoxic therapies)	A	A(9)	(124, 192, 209)
14. Evaluation in HCM				
Q45	In HCM patients with inconclusive or inadequate echocardiography	A	A(9)	(205, 207, 208, 215)
Q46	To define apical hypertrophy and/or aneurysm if echocardiography is inconclusive	A	A(9)	(205, 207, 208, 215)
Q47	In selected patients with known HCM, when sudden cardiac death risk stratification is inconclusive after documentation of the conventional risk factors/Use of LGE evaluation	A	A(8)	(126, 221)
Miscellaneous				
Q48	**15. Evaluation of Cardiac Mass (Suspected Tumor or Thrombus)/**Use of Contrast for Perfusion and Enhancement	A	A(9)	(231-234)
Q49	**16. Evaluation of Pericardium (Pericardial Mass, Constrictive Pericarditis)**	B	A(8)	(236, 237, 239)
Q50	**17. Evaluation for Aortic Dissection**	A	A(8)	(240)
Q51	**18. Evaluation of Pulmonary Veins Prior to Radiofrequency Ablation for Atrial Fibrillation**/Left Atrial and Pulmonary Venous Anatomy Including Dimensions of Veins for Mapping Purposes	B	A(7)	(241-243)
Q52	**19. Anatomic Assessment Before Percutaneous Device Closure of ASD or VSD**/Anatomic Assessment Before Percutane-	B	A(7)	(244, 245, 247)

	ous Device Closure or Percutaneous Aortic Valve Replacement			

Table 2. Uncertain Indications (Median score 4-6)

Indication		Level of Evi-dence	Appro-priate-ness Criteria (score)	References
1. Evaluation of Chest Pain Syndrome *(Protocols may include vasodilator perfusion CMR, dobutamine stress function CMR, and/or MR coronary angiography)*				
Q2	Intermediate pre-test probability of CAD/ECG interpretable AND able to exercise	A	U(4)	(13, 34, 39, 65)
Q4	High pre-test probability of CAD	A	U(6)	(13, 34, 39, 65)
3. Acute Chest Pain *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
Q6	Low pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	A	U(4)	(48, 51, 52)
Q7	Intermediate pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	A	U(5)	(48, 51)
Q8	High pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	A	U(5)	(48, 51)
4. Detection of CAD: with Prior Test Results *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
Q11	Equivocal stress test (exercise, stress SPECT, or stress echo)/ Intermediate CHD risk (Framingham)	A	U(6)	(13, 17, 65)
5. Evaluation of CAD: Post PCI or CABG *Evaluation of Chest Pain Syndrome (Use of MR Coronary Angiography)*				
Q13	Evaluation of bypass grafts	C	U(4)	(69, 70)
6. CAD Risk Assessment: Preoperative Evaluation *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
Q18	Intermediate or high risk non-cardiac surgery in patients with intermediate perioperative risk predictors	C	U(5)	(82)
Q19	CAD evaluation before valve surgery	C	U(6)	(82)
7. Evaluation of CAD: In Pediatric Patients with Kawasaki Disease *(Use of MR Coronary Angiography)*				
Asymptomatic				

Q20	No previous definitive test (catheter-based XCA, MR coronary angiography, or CT coronary angiography) available	B	U(5)	(84, 85, 87)
8. Detection of CAD: Asymptomatic *(Protocols may include vasodilator perfusion CMR, dobutamine stress function CMR, and/or MR coronary angiography)*				
Q25	Moderate CHD risk (Framingham)	A	U(4)	(89)
Q26	High CHD risk (Framingham)	A	U(6)	(89)

Table 3. Inappropriate Indications (Median score 1-3)

Indication		Level of Evi-dence	Appro-priate-ness Criteria (score)	References
1. Evaluation of Chest Pain Syndrome *(Protocols may include vasodilator perfusion CMR, dobutamine stress function CMR, and/or MR coronary angiography)*				
Q1	Low pre-test probability of CAD/ECG interpretable AND able to exercise	A	I(2)	(13, 34, 39, 65)
3. Acute Chest Pain *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
Q9	High pre-test probability of CAD/ECG—ST-segment elevation and/or positive cardiac enzymes	A	I(2)	(48, 51)
4. Detection of CAD: with Prior Test Results *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
Q10	Normal prior stress test (exercise, nuclear, echo, MRI)/High CHD risk (Framingham)/Within 1 year of prior stress test	A	I(2)	(13, 17, 65)
5. Evaluation of CAD: Post PCI or CABG *Evaluation of Chest Pain Syndrome (Use of MR Coronary Angiography)*				
Q14	History of percutaneous revascularization with stents	C	I(3)	(71, 72)
Asymptomatic (Use of MR Coronary Angiography)				
Q15	Evaluation of bypass grafts and coronary anatomy	C	I(3)	(69, 70)
Q16	Evaluation for in-stent restenosis and coronary anatomy after PCI	C	I(3)	(71, 72)
6. CAD Risk Assessment: Preoperative Evaluation *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
Q17	Low-risk non-cardiac surgery in patients with intermediate	C	I(3)	(82)

	perioperative risk predictors			
8. Detection of CAD: Asymptomatic *(Protocols may include vasodilator perfusion CMR, dobutamine stress function CMR, and/or MR coronary angiography)*				
Q24	Low CHD risk (Framingham)	A	I(1)	(89)
10. Evaluation in Patients with Risk of Heart Failure or Overt Heart Failure (General) *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*				
Q38	Cardiac function follow up after ICD or CRT	C	I(3)	(138, 139)

3. Definitions and Process for Determining Likelihood of Disease and Risk

Definition of Chest Pain Syndrome

Any constellation of symptoms that the physician feels may represent a complaint consistent with obstructive CAD (e.g., chest pain, chest tightness, burning sensation, dyspnea, shoulder pain, and jaw pain, etc.).

Definition of Angina

As defined by the ACC/AHA 2002 Guideline Update on Exercise Testing

1. Typical Angina (Definite): 1) Substernal pain or discomfort that is 2) provoked by exertion or emotional stress and 3) relieved by rest and/or nitroglycerin
2. Atypical Angina (Probable): Chest pain or discomfort that lacks one of the characteristics of typical angina
3. Non-anginal Chest Pain: Chest pain or discomfort that meets one or none of the typical angina characteristics

Determining Pretest Probability of CAD

As modified by the ACC/AHA guideline for chronic stable angina

Age	Sex	Typical Angina	Atypical Angina	Nonanginal Chest Pain	Asymptomatic
≤39	Male	Intermediate	Intermediate	Low	Very low
	Female	Intermediate	Very low	Very low	Very low
40-49	Male	High	Intermediate	Intermediate	Low
	Female	Intermediate	Low	Very low	Very low
50-59	Male	High	Intermediate	Intermediate	Low
	Female	Intermediate	Intermediate	Low	Very low
≥60	Male	High	Intermediate	Intermediate	Low
	Female	High	Intermediate	Intermediate	Low

High: Greater than 90% pre-test probability, Intermediate: Between 10% and 90% pre-test probability, Low: Between 5% and 10% pre-test probability, Very Low: Less than 5% pre-test probability. No data exist for patients less than 30 years or greater than 69 years, but it can be assumed that prevalence of CAD increases with age.

Determining Risk Assessment of Coronary Heart Disease (CHD) in Asymptomatic Patients

Estimation of CHD risk is determined according to the methods of Adult Treatment Panel Ⅲ report.

1. Low CHD Risk: The age-specific risk level is below average (10-year absolute CHD risk <10%).
2. Intermediate CHD Risk: The age-specific risk level is average or above average (10-year absolute CHD risk between 10% to 20%).
3. High CHD Risk: The presence of diabetes mellitus in a patient ≥40 years of age, peripheral arterial disease or other coronary risk equivalents, or 10-year absolute CHD risk of >20%.

4. Quality Assessment of Guidelines by K-AGREE

	Domain 1. Scope and Purpose	Domain 2. Stakeholder Involvement	Domain 3. Rigour of Development	Domain 4. Clarity of Presentation	Domain 5. Applicability	Domain 6. Editorial Independence
Guideline 1 (SCMR 2004)	22.2	19.4	10.4	25.0	20.8	12.5
Guideline 2 (ACCF 2006)	72.2	38.9	26.0	58.3	33.3	83.3
Guideline 3 (ASCI 2010)	58.3	36.1	21.9	58.3	22.9	29.2
Guideline 4 (IHD 2007)	38.9	47.2	51	38.9	20.8	20.8
Guideline 5 (HCMP 2011)	94.4	77.8	81.3	88.9	47.9	87.5
Guideline 6 (HF 2013)	86.1	69.4	69.8	86.1	45.8	91.7

Guideline 1 Clinical indications for cardiovascular magnetic resonance (CMR): Consensus Panel report

Guideline 2 ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR 2006 appropriateness criteria for cardiac computed tomography and cardiac magnetic resonance imaging

Guideline 3 ASCI 2010 appropriateness criteria for cardiac magnetic resonance imaging: a report of the Asian Society of Cardiovascular Imaging cardiac computed tomography and cardiac magnetic resonance imaging guideline working group

Guideline 4 CCS/CAR/CANM/CNCS/CanSCMR joint position statement on advanced noninvasive cardiac imaging using positron emission tomography, magnetic resonance imaging and multidetector computed tomographic angiography in the diagnosis and evaluation of ischemic heart disease

Guideline 5 2011 ACCF/AHA guideline for the diagnosis and treatment of hypertrophic cardiomyopathy: Executive summary: A report of the American College of cardiology foundation/American heart association task force on practice guidelines

Guideline 6 2013 ACCF/ACR/ASE/ASNC/SCCT/SCMR Appropriate Utilization of Cardiovascular Imaging in Heart Failure: A Joint Report of the American College of Radiology Appropriateness Criteria Committee and the American College of Cardiology Foundation Appropriate Use Criteria Task Force

5. Guideline Matrix

Table 1. Detection of CAD

		2006 ACCF	2010 ASCI	2007 Can IHD
Detection of CAD: Symptomatic				
Evaluation of Chest Pain Syndrome *(Protocols may include vasodilator perfusion* CMR, dobutamine stress function† CMR, and/or MR coronary angiography‡)*				
1	Low pre-test probability of CAD/ECG interpretable AND able to exercise	2	2	I*, IIa†, IIb‡/B
2	Intermediate pre-test probability of CAD/ECG interpretable AND able to exercise	4	4	
3	Intermediate pre-test probability of CAD/ECG uninterpretable OR unable to exercise	7	7	
4	High pre-test probability of CAD	5	6	
Evaluation of Intracardiac Structures *(Use of MR Coronary Angiography)*				
5	Evaluation of suspected coronary anomalies	8	8	I/C
Acute Chest Pain *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
6	Low pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	-	4	-
7	Intermediate pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	6	5	-
8	High pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	-	5	-
9	High pre-test probability of CAD/ECG—ST-segment elevation and/or positive cardiac enzymes	1	2	-
Detection of CAD: with Prior Test Results *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
10	Normal prior stress test (exercise, nuclear, echo, MRI)/High CHD risk (Framingham)/Within 1 year of prior stress test	2	3	-.
11	Equivocal stress test (exercise, stress SPECT, or stress echo)/Intermediate CHD risk (Framingham)	6	6	-
12	Coronary angiography (catheterization or CT)/Stenosis of unclear significance	7	7	-
Evaluation of CAD: Post PCI or CABG				
Evaluation of Chest Pain Syndrome (Use of MR Coronary Angiography)				

13	Evaluation of bypass grafts	2	5	IIb/C
14	History of percutaneous revascularization with stent	1	4	-
Asymptomatic (Use of MR Coronary Angiography)				
15	Evaluation of bypass grafts and coronary anatomy	-	4	-
16	Evaluation for in-stent restenosis and coronary anatomy after PCI	-	3	-
CAD Risk Assessment: Preoperative Evaluation *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*				
17	Low-risk non-cardiac surgery in patients with intermediate perioperative risk predictors	2	3	-
18	Intermediate or high risk non-cardiac surgery in patients with intermediate perioperative risk predictors	6	5	-
19	CAD evaluation before valve surgery	-	6	-
Evaluation of CAD: in pediatric patients with Kawasaki disease *(Use of MR coronary angiography)*				
Asymptomatic				
20	No previous definitive test (catheter-based XCA, MR coronary angiography, or CT coronary angiography) available	-	5	-
21	Previous tests (catheter-based XCA, MR coronary angiography, or CT coronary angiography) documented coronary aneurysm/stenosis, for follow up	-	7	-
Symptomatic				
22	No previous definitive test (catheter-based XCA, MR coronary angiography, or CT coronary angiography) available	-	7	-
23	Previous tests (catheter-based XCA, MR coronary angiography, or CT coronary angiography) documented coronary aneurysm/stenosis, for follow up	-	7	-
Detection of CAD: Asymptomatic *(Protocols may include vasodilator perfusion* CMR, dobutamine stress function† CMR, and/or MR coronary angiography‡)*				
24	Low CHD risk (Framingham)	-	1	-
25	Moderate CHD risk (Framingham)	-	4	-
26	High CHD risk (Framingham)	-	6	-

		2006 ACCF	2010 ASCI	2007 Can IHD	2013 HF§
Detection of Myocardial Scar and Viability in Ischemic Heart Disease *(Protocols may include LGE evaluation or dobutamine stress function CMR)*					
27	To determine the location and extent of myocardial necrosis including 'no reflow' regions/Post-acute myocardial infarction	7	9	-	-
28	To detect post PCI myocardial necrosis	4	8	-	-

29	To determine viability prior to revascularization/Establish likelihood of recovery of function with revascularization (PCI or CABG) or medical therapy	9	9	I/B	A
30	To determine viability prior to revascularization/Viability assessment by SPECT or dobutamine echo has provided "equivocal or indeterminate" results	9		-	-

§ **A** (Appropriate Score 7 to 9), **M** (Maybe Appropriate Score 4 to 6), **R** (Rarely Appropriate Score 1 to 3)

Table 2. Structure and Myocardial Functional Evaluation in Patients with Risk of Heart Failure or Overt Heart Failure

		2006 ACCF	2010 ASCI	2013 HF§	2011 HCM
Evaluation in Patients with Risk of Heart Failure or Overt Heart Failure (General) *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*					
31	Evaluation of LV function following myocardial infarction OR in heart failure patients	6	8	A	-
32	Evaluation of LV function following myocardial infarction OR in heart failure patients/Patients with technically limited images from echocardiogram	8	9	-	-
33	Quantification of LV function/Discordant information that is clinically significant from prior tests	8	9	-	-
34	Evaluation in patients with new onset heart failure to assess etiology	-	8	A	-
35	Initial evaluation of structure and function for newly suspected or potential heart failure (also including malignancy on current or planned cardiotoxic therapy and no prior imaging evaluation/familial or genetic cardiomyopathy in first-degree relative, known adult congenital heart disease, acute myocardial infarction during initial hospitalization)	-	-	A	-
36	Evaluation determine patient candidacy of ICD therapy (ejection fraction and/or other structural information)	-	-	A	-
37	Initial evaluation determine patient candidacy of CRT or procedural planning (ejection fraction, fibrosis, scarring, coronary vein variation, and intra-cavitary thrombus)	-	-	A	-
38	Cardiac function follow up after ICD or CRT	-	-	R	-
In Congenital Heart Disease *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*					

39	Assessment of complex congenital heart disease including anomalies of coronary circulation, great vessels, and cardiac chambers and valves	9	8	A	-
40	Assessment of post-operative congenital heart disease including ventricular and valvular function and anatomy evaluation	-	8	-	-
In Valvular Heart Disease *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*					
41	Characterization of native and prosthetic cardiac valves—including planimetry of stenotic disease and quantification of regurgitant disease/Patients with technically limited images from transthoracic or transesophageal echocardiography	8	7	-	-
In Suspected or diagnosed Myocardial Disease (*Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*					
42	Evaluation for ARVD/C patients presenting with syncope or ventricular arrhythmia	9	8	-	-
43	Evaluation of myocarditis or myocardial infarction with normal coronary arteries/Positive cardiac enzymes without obstructive atherosclerosis on angiography	8	9	-	-
44	Evaluation of specific cardiomyopathies (infiltrative [amyloid, sarcoid, etc.] or due to cardiotoxic therapies)	8	9	-	IIb/C
Evaluation in HCM					
45	In HCM patients with inconclusive or inadequate echocardiography	-	-	-	I/B
46	To define apical hypertrophy and/or aneurysm if echocardiography is inconclusive	-	-	-	IIa/C
47	In selected patients with known HCM, when SCD risk stratification is inconclusive after documentation of the conventional risk factors/Use of LGE evaluation	-	-	-	IIb/C

§ **A** (Appropriate Score 7 to 9), **M** (Maybe Appropriate Score 4 to 6), **R** (Rarely Appropriate Score 1 to 3)

Table 3. Miscellaneous

		2006 ACCF	2010 ASCI
48	Evaluation of Cardiac Mass (Suspected Tumor or Thrombus)/Use of Contrast for Perfusion and Enhancement	9	9
49	Evaluation of Pericardium (Pericardial mass, Constrictive Pericarditis)	8	8
50	Evaluation for Aortic Dissection	8	-

51	Evaluation of Pulmonary Veins Prior To Radiofrequency Ablation for Atrial Fibrillation/Left Atrial and Pulmonary Venous Anatomy Including Dimensions of Veins for Mapping Purposes	8	7
52	Anatomic Assessment Before Percutaneous Device Closure of ASD or VSD/Anatomic Assessment Before Percutaneous Device Closure or Percutaneous Aortic Valve Replacement	-	7

6. Delphi Summary

Table 1. Detection of CAD

		Appropriateness Criteria (Median Score)	Agreement Round	Appropriate (A)	Uncertain (U)	Inappropriate (I)
Detection of CAD: Symptomatic						
1. Evaluation of Chest Pain Syndrome *(Protocols may include vasodilator perfusion CMR, dobutamine stress function CMR, and/or MR coronary angiography)*						
Q1	Low pre-test probability of CAD/ECG interpretable AND able to exercise	I(2)	1	0%	10%	90%
Q2	Intermediate pre-test probability of CAD/ECG interpretable AND able to exercise	U(4)	1	5%	80%	15%
Q3	Intermediate pre-test probability of CAD/ECG uninterpretable OR unable to exercise	A(7)	1	85%	10%	5%
Q4	High pre-test probability of CAD	U(6)	1	20%	80%	0%
2. Evaluation of Intracardiac Structures *(Use of MR Coronary Angiography)*						
Q5	Evaluation of suspected coronary anomalies	A(8)	1	95%	5%	0%
3. Acute Chest Pain *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*						
Q6	Low pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	U(4)	1	0%	70%	30%
Q7	Intermediate pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	U(5)	1	10%	85%	5%
Q8	High pre-test probability of CAD/No ECG changes and serial cardiac enzyme negative	U(5)	1	5%	85%	10%
Q9	High pre-test probability of CAD/ECG—ST-segment elevation and/or positive cardiac enzymes	I(2)	1	0%	5%	95%
4. Detection of CAD: with Prior Test Results *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*						
Q10	Normal prior stress test (exercise, nuclear, echo, MRI)/High CHD risk (Framingham)/Within 1 year of prior stress test	I(2)	1	0%	10%	90%
Q11	Equivocal stress test (exercise, stress SPECT, or stress echo)/Intermediate CHD risk (Fram-	U(6)	1	25%	75%	0%

	ingham)					
Q12	Coronary angiography (catheterization or CT)/Stenosis of unclear significance	A(7)	1	95%	5%	0%
5. Evaluation of CAD: Post PCI or CABG						
Evaluation of Chest Pain Syndrome (Use of MR Coronary Angiography)						
Q13	Evaluation of bypass grafts	U(4)	2	0%	75%	25%
Q14	History of percutaneous revascularization with stents	I(3)	2	0%	15%	85%
Asymptomatic (Use of MR Coronary Angiography)						
Q15	Evaluation of bypass grafts and coronary anatomy	I(3)	2	0%	5%	95%
Q16	Evaluation for in-stent restenosis and coronary anatomy after PCI	I(3)	1	0%	0%	100%
6. CAD Risk Assessment: Preoperative Evaluation *(Protocols may include vasodilator perfusion CMR or dobutamine stress function CMR)*						
Q17	Low-risk non-cardiac surgery in patients with intermediate perioperative risk predictors	I(3)	1	0%	5%	95%
Q18	Intermediate or high risk non-cardiac surgery in patients with intermediate perioperative risk predictors	U(5)	1	5%	95%	0%
Q19	CAD evaluation before valve surgery	U(6)	1	20%	75%	5%
7. Evaluation of CAD: In Pediatric Patients with Kawasaki Disease *(Use of MR Coronary Angiography)*						
Asymptomatic						
Q20	No previous definitive test (catheter-based XCA, MR coronary angiography, or CT coronary angiography) available	U(5)	1	10%	85%	5%
Q21	Previous tests (catheter-based XCA, MR coronary angiography, or CT coronary angiography) documented coronary aneurysm/stenosis, for follow up	A(7)	1	80%	15%	5%
Symptomatic						
Q22	No previous definitive test (catheter-based XCA, MR coronary angiography, or CT coronary angiography) available	A(7)	1	85%	15%	0%
Q23	Previous tests (catheter-based XCA, MR coronary angiography, or CT coronary angiography) documented coronary aneurysm/stenosis, for follow up	A(7)	1	85%	15%	0%

8. Detection of CAD: Asymptomatic *(Protocols may include vasodilator perfusion CMR, dobutamine stress function CMR, and/or MR coronary angiography)*						
Q24	Low CHD risk (Framingham)	I(1)	1	0%	0%	100%
Q25	Moderate CHD risk (Framingham)	U(4)	1	0%	80%	20%
Q26	High CHD risk (Framingham)	U(6)	2	10%	85%	5%

Table 2. Detection of Myocardial Scar and Viability in Ischemic Heart Disease

		Appropriateness Criteria (Median Score)	Agreement Round	Appropriate (A)	Uncertain (U)	Inappropriate (I)
9. Detection of Myocardial Scar and Viability *(Protocols may include LGE evaluation or dobutamine stress function CMR)*						
Q27	To determine the location and extent of myocardial necrosis including 'no reflow' regions/Post-acute myocardial infarction	A(9)	1	100%	0%	0%
Q28	To detect post PCI myocardial necrosis	A(8)	1	90%	10%	0%
Q29	To determine viability prior to revascularization/Establish likelihood of recovery of function with revascularization (PCI or CABG) or medical therapy	A(9)	1	100%	0%	0%
Q30	To determine viability prior to revascularization/Viability assessment by SPECT or dobutamine echo has provided "equivocal or indeterminate" results	A(9)	1	100%	0%	0%

Table 3. Structure and Myocardial Functional Evaluation in Patients with Risk of Heart Failure or Overt Heart Failure

		Appropriateness Criteria (Median Score)	Agreement Round	Appropriate (A)	Uncertain (U)	Inappropriate (I)
10. Evaluation in Patients with Risk of Heart Failure or Overt Heart Failure (General) *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*						
Q31	Evaluation of LV function following myocardial infarction OR in heart failure patients	A(7)	1	90%	10%	0%

Q32	Evaluation of LV function following myocardial infarction OR in heart failure patients/ Patients with technically limited images from echocardiogram	A(9)	1	100%	0%	0%
Q33	Quantification of LV function/Discordant information that is clinically significant from prior tests	A(9)	1	100%	0%	0%
Q34	Evaluation in patients with new onset heart failure to assess etiology	A(8)	1	100%	0%	0%
Q35	Initial evaluation of structure and function for newly suspected or potential heart failure (also including malignancy on current or planned cardiotoxic therapy and no prior imaging evaluation/familial or genetic cardiomyopathy in first-degree relative, known adult congenital heart disease, acute myocardial infarction during initial hospitalization)	A(8)	1	90%	10%	0%
Q36	Evaluation determine patient candidacy of ICD therapy (ejection fraction and/or other structural information)	A(8)	1	90%	10%	0%
Q37	Initial evaluation determine patient candidacy of CRT or procedural planning (ejection fraction, fibrosis, scarring, coronary vein variation, and intra-cavitary thrombus)	A(8)	1	90%	10%	0%
Q38	Cardiac function follow up after ICD or CRT	I(3)	3	10%	20%	70%
11. In Congenital Heart Disease *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*						
Q39	Assessment of complex congenital heart disease including anomalies of coronary circulation, great vessels, and cardiac chambers and valves	A(8)	1	100%	0%	0%
Q40	Assessment of post-operative congenital heart disease including ventricular and valvular function and anatomy evaluation	A(8)	1	95%	5%	0%
12. In Valvular Heart Disease *(Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*						

Q41	Characterization of native and prosthetic cardiac valves—including planimetry of stenotic disease and quantification of regurgitant disease/ Patients with technically limited images from transthoracic or transesophageal echocardiography	A(7.5)	1	85%	15%	0%
13. In Suspected or Diagnosed Myocardial Disease (*Protocols may include LV/RV mass and volumes, MR angiography, quantification of valvular disease, and LGE evaluation)*						
Q42	Evaluation for ARVD/C patients presenting with syncope or ventricular arrhythmia	A(9)	1	100%	0%	0%
Q43	Evaluation of myocarditis or myocardial infarction with normal coronary arteries/ Positive cardiac enzymes without obstructive atherosclerosis on angiography	A(9)	1	100%	0%	0%
Q44	Evaluation of specific cardiomyopathies (infiltrative [amyloid, sarcoid, etc.] or due to cardiotoxic therapies)	A(9)	1	100%	0%	0%
14. Evaluation in HCM						
Q45	In HCM patients with inconclusive or inadequate echocardiography	A(9)	1	100%	0%	0%
Q46	To define apical hypertrophy and/or aneurysm if echocardiography is inconclusive	A(9)	1	95%	5%	0%
Q47	In selected patients with known HCM, when SCD risk stratification is inconclusive after documentation of the conventional risk factors/Use of LGE evaluation	A(8)	1	85%	15%	0%

Table 4. Miscellaneous

		Appropriateness Criteria (Median Score)	Agreement Round	Appropriate (A)	Uncertain (U)	Inappropriate (I)
Q48	**15. Evaluation of Cardiac Mass (Suspected Tumor or Thrombus)**/Use of Contrast for Perfusion and Enhancement	A(9)	1	100%	0%	0%
Q49	**16. Evaluation of Pericardium (Pericardial Mass, Constrictive Pericarditis)**	A(8)	1	100%	0%	0%
Q50	**17. Evaluation for Aortic Dissection**	A(8)	1	85%	15%	0%

Q51	**18. Evaluation of Pulmonary Veins Prior to Radiofrequency Ablation for Atrial Fibrillation**/Left atrial and Pulmonary Venous Anatomy Including Dimensions of Veins for Mapping Purposes	A(7)	1	90%	10%	0%
Q52	**19. Anatomic Assessment Before Percutaneous Device Closure of ASD or VSD**/Anatomic Assessment Before Percutaneous Device Closure or Percutaneous Aortic Valve Replacement	A(7)	1	80%	20%	0%

7. Literature Review Strategies

(1) Search for Guidelines

A comprehensive search of previous publications on CMR application and related guidelines was done for the adaptive development. The following search field settings were used for each database.

PubMed (www.pubmed.gov)

PICO	Mesh Terms	Title/Abstract
P	"heart"[MeSH]	"heart"[TIAB] OR "cardiac"[TIAB]
	"Heart Diseases"[MeSH]	"Heart Diseases"[TIAB]
		("Heart"[TIAB] AND "Diseases"[TIAB])
I	"magnetic resonance imaging"[MeSH]	("magnetic"[TIAB] AND "resonance"[TIAB] AND "imaging"[TIAB]) OR "magnetic resonance imaging"[TIAB]
		("magnetic"[TIAB] AND "resonance"[TIAB]) OR "magnetic resonance"[TIAB] OR "mr"[TIAB] OR "mri"[TIAB]

For the Pubmed database, ("heart"[MeSH Terms] OR "heart"[TIAB] OR "cardiac"[TIAB] OR "Heart Diseases"[TIAB] OR ("Heart"[TIAB] AND "Diseases"[TIAB]) OR "Heart Diseases"[MeSH Terms]) AND (("magnetic"[TIAB] AND "resonance"[TIAB]) OR "magnetic resonance"[TIAB] OR "mri"[TIAB] OR "magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[TIAB] AND "resonance"[TIAB] AND "imaging"[TIAB]) OR "magnetic resonance imaging"[TIAB]) AND (Guideline[ptyp] OR Practice Guideline[ptyp]) AND ("2000/01/01"[PDAT] : "3000/12/31"[PDAT]) was used to filter publication searches. Of these, 54 related publications were reviewed.

Cochrane Library (www.interscience.wiley.com)

No.	Search	Results
#1	MeSH descriptor: [Heart] explode all trees	5,219
#2	MeSH descriptor: [Heart Diseases] explode all trees	33,700
#3	heart or cardiac:ti,ab,kw (Word variations have been searched)	64,088
#4	Heart Diseases:ti,ab,kw	186
#5	#1 or #2 or #3 or #4	76,077
#6	MeSH descriptor: [Magnetic Resonance Imaging] explode all trees	4,621
#7	Magnetic Resonance Imaging:ti,ab,kw	9
#8	MRI	3,571
#9	#6 or #7 or #8	6,275
#10	MeSH descriptor: [Guideline] explode all trees	16
#11	MeSH descriptor: [Practice Guideline] explode all trees	13

#12	Practice Guideline or Guideline	14,150
#13	#10 or #11 or #12	14,150
#14	#5 and #9 and #13	43
#15	#14 from 2000 to 2013	40

For the Cochrane Library, above search strategy was uses to filter publication searches and 40 related publications were reviewed.

Embase (www.embase.com)

No.	Query	Results
#1	heart'/exp	588,122
#2	heart disease'/exp	1,256,355
#3	cardiac OR heart	2,164,164
#4	#1 OR #2 OR #3	2,164,164
#5	nuclear magnetic resonance imaging'/exp	470,289
#6	nuclear magnetic resonance'/exp	730,813
#7	magnetic resonance imaging	497,248
#8	MRI	198,734
#9	#5 OR #6 OR #7 OR #8	768,002
#10	practice guideline'/de	212,721
#11	#4 AND #9 OR #10	978
#12	#11 AND [humans]/lim AND [embase]/lim AND [2000-2013]/py	881
#13	#12 AND ([controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim)	55

For the Embase, above search strategy was uses to filter publication searches and 55 related publications were reviewed.

National Guideline Clearing House (http://www.guideline.gov/)

Keyword: (heart OR cardiac) AND (magnetic resonance imaging OR MRI)

Clinical Specialty: Cardiology, Radiation Oncology, Radiology, Thoracic Surgery

Publication Year: 2000-2013

These search field settings were used and 148 publications were found. Of these, 51 related publications were reviewed after additional title filtering by chest OR heart OR card* OR arter* OR artri* OR thorac* OR angina on EndNote program.

Scottish Intercollegiate Guidelines Network (SIGN)

(http://www.sign.ac.uk/guidelines/index.html)

Five guidelines (guideline number 93-97) about cardiac disease were reviewed.

National Institute for Clinical Excellence (NICE) (http://www.nice.org.uk/)

No.	Query	Results
#1	(heart OR cardiac) AND (magnetic resonance imaging OR MRI)	3,317
#2	#1 Filter by Types : Guideline	631
#3	#2 Filter by Sources : NICE, British thoracic society, Royal college of physicians of London, Royal college of Radiologists	130
#4	#3 Filter by Years : 2000-2013	130

These search field settings were used and 130 publications were found. Of these, 6 related publications were reviewed after additional title filtering by chest OR heart OR card* OR arter* OR artri* OR thorac* OR angina on EndNote program.

(2) Literature Searches for Evidence

1. Detection of Coronary Artery Disease (CAD): Symptomatic

Scenario 1: Evaluation of chest pain syndrome

For the PubMed database, cardiac AND (Magnetic Resonance Imaging OR magnetic resonance OR MR) AND (coronary artery disease OR CAD OR electrocardiogram OR ECG) AND (Exercise Test OR exercise) AND (("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) and cardiac AND (Magnetic Resonance Imaging OR magnetic resonance OR MR) AND (coronary artery disease OR CAD) AND (("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) were used to filter publication searches, 16 and 97 RCTs, 2 and 8 Meta-analysis, 14 and 64 Systemic Reviews were found. Of these, 7 related publications were reviewed. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 115 and 268 publications, respectively. Search field settings of (cardiac OR 'heart'/exp OR heart) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('coronary artery disease'/exp OR 'electrocardiogram'/exp OR 'coronary artery disease' OR cad OR 'electrocardiogram' OR electrocardiography OR ecg) AND ('exercise test'/exp OR 'exercise'/exp OR 'exercise test' OR exercise) AND [english]/lim NOT [medline]/lim AND [2000-2013]/py and (cardiac OR 'heart'/exp OR heart) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('coronary artery disease'/exp OR 'coronary artery disease' OR cad) AND [english]/lim NOT [medline]/lim AND [2000-2013]/py were used to search the Embase database and 9 and 24 RCTs, 5 and 22 Meta-analysis, 6 and 17 Systemic Reviews were found. Of these, 42 related publications were reviewed.

Scenario 2: Evaluation of coronary artery anomaly (Use of MR coronary angiography)

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND coronary angiography AND (coronary AND (anomaly OR anomalies OR abnormal)) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] was used to filter publication searches and 12 publications were found. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 4 publications. Search field settings of

('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging OR magnetic AND resonance) OR mr OR mri) AND ('angiocardiography'/exp OR (angiocardiography OR coronary AND angiography)) AND ('coronary artery anomaly'/exp OR coronary AND (anomal* OR abnormal*)) AND [english]/lim NOT [medline]/lim AND [2000-2013]/py were used to search the Embase database and 11 publications were found. Of these, 8 related publications were reviewed.

Scenario 3: Evaluation of acute chest pain

For the PubMed database, cardiac AND (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (coronary artery disease OR CAD OR electrocardiogram OR ECG) AND cardiac enzyme AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] was used to filter publication searches and 15 publications were found. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 12 publications. Search field settings of (cardiac OR 'heart'/exp OR heart) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('coronary artery disease'/exp OR 'electrocardiogram'/exp OR 'coronary artery disease' OR cad OR 'electrocardiogram' OR electrocardiography OR ecg) AND ('enzyme'/exp OR enzymes OR enzyme) AND [english]/lim NOT [medline]/lim AND [2000-2013]/py were used to search the Embase database and 38 publications were found. Of these, 6 related publications were reviewed.

Scenario 4: Detection of CAD with prior test results

For the PubMed database, cardiac AND (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (echocardiography stress test OR magnetic resonance imaging stress OR MRI stress test OR nuclear stress test OR stress SPECT OR stress single-photon emission-computed tomography OR stress test OR stress) AND (CHD OR coronary heart disease) AND (risk factors OR framingham risk score OR framingham OR risk) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] was used to filter publication searches and 22 publications were found. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 71 publications. Search field settings of (cardiac OR 'heart'/exp OR heart) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('stress echocardiography'/exp OR (('single photon emission computer tomography'/exp OR 'single photon emission computer tomography' OR spect OR 'nuclear magnetic resonance imaging'/exp OR 'magnetic resonance imaging' OR mri OR mr OR 'echocardiography'/exp OR echocardiograph*) AND ('exercise test'/exp OR stress AND test OR stress))) AND ('ischemic heart disease'/exp OR coronary heart disease OR CHD) AND ('risk factor'/exp OR risk AND factor* OR 'framingham risk score'/exp OR (framingham AND risk AND score) OR framingham OR risk) AND [english]/lim AND [humans]/lim AND [2000-2013]/py NOT [medline]/lim were used to search the Embase database and 16 publications were found. Of these, 14 related publications were reviewed.

Scenario 5: Evaluation of CAD in patients with post PCI or CABG

(1) Evaluation of coronary stents

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND Coronary angiography AND (Post[All Fields] OR after[All] OR ("postoperative period"[MeSH Terms] OR ("postoperative"[All Fields] AND "period"[All Fields]) OR "postoperative period"[All Fields] OR "postoperative"[All Fields])) AND ((percutaneous[TIAB] AND ("heart"[MeSH Terms] OR "heart"[TIAB] OR "coronary"[TIAB]) AND intervention[TIAB]) OR stent[TIAB] OR "Stents"[Mesh]) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] was used to filter publication searches and 41 publications were found. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 11 publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('angiocardiography'/exp OR Coronary angiograph*) AND ('postoperative period'/exp OR post OR after) AND ((percutaneous AND ('heart'/exp OR heart OR coronary) AND intervention) OR 'percutaneous coronary intervention'/exp OR 'stent'/exp OR stent OR Stents) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim were used to search the Embase database and 12 publications were found. Of these, 4 related publications were reviewed.

(2) Evaluation of CABG

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND Coronary angiography AND (Post[All Fields] OR after[All] OR ("postoperative period"[MeSH Terms] OR ("postoperative"[All Fields] AND "period"[All Fields]) OR "postoperative period"[All Fields] OR "postoperative"[All Fields])) AND (("coronary artery bypass"[MeSH Terms] OR ("coronary"[TIAB] AND "artery"[TIAB] AND "bypass"[TIAB]) OR "coronary artery bypass"[TIAB] OR ("coronary"[TIAB] AND "artery"[TIAB] AND "bypass"[TIAB] AND "graft"[TIAB]) OR "coronary artery bypass graft"[TIAB]) OR ("coronary artery bypass"[MeSH Terms] OR ("coronary"[TIAB] AND "artery"[TIAB] AND "bypass"[TIAB]) OR "coronary artery bypass"[TIAB]) OR CABG[TIAB]) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] was used to filter publication searches and 10 publications were found. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 9 publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('angiocardiography'/exp OR Coronary angiograph*) AND ('postoperative period'/exp OR post OR after) AND ('coronary artery bypass graft'/exp OR GABG OR bypass) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim were used to search the Embase database and 13 publications were found. Of these, 2 related publications were reviewed.

Scenario 6: CAD risk assessment: preoperative evaluation

(1) preoperative evaluation

For the PubMed database, cardiac AND (Magnetic Resonance Imaging OR magnetic resonance OR

MR OR MRI) AND ("Perioperative Period"[Mesh] OR perioperativ* OR after OR before OR preoperativ*) AND (Noncardiac surgery OR Vascular surgery OR Cardiac evaluation) AND (Risk assessment OR Risk factor OR Risk) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] was used to filter publication searches and 62 publications were found. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 13 publications. Search field settings of (cardiac OR 'heart'/exp OR heart) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('perioperative period'/exp OR perioperativ* OR after OR before OR preoperativ*) AND (Noncardiac surgery OR Vascular surgery OR Cardiac evaluation) AND (Risk assessment OR Risk factor OR Risk) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim were used to earch the Embase database and 23 publications were found. Of these, 9 related publications were reviewed.

(2) before valve surgery

For the PubMed database, cardiac AND (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND ("Preoperative Period"[Mesh] OR before OR preoperativ*) AND ("Heart Valve Prosthesis"[Mesh] OR "Heart Valve Prosthesis Implantation"[Mesh] OR "Cardiac Valve Annuloplasty"[Mesh] OR Valve surgery) AND (coronary artery disease OR CAD) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] was used to filter publication searches and 50 publications were found. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 18 publications. Search field settings of (cardiac OR 'heart'/exp OR heart) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('preoperative period'/exp OR before OR preoperativ*) AND ('heart valve prosthesis'/exp OR 'heart valve replacement'/exp OR 'annuloplasty'/exp OR valve surger*) AND ('coronary artery disease'/exp OR coronary artery diseas* OR CAD) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim were used to search the Embase database and 95 publications were found. Of these, 4 related publications were reviewed.

Scenario 7: Evaluation of CAD in pediatric patients with Kawasaki disease

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND angiography AND (("mucocutaneous lymph node syndrome"[MeSH Terms] OR ("mucocutaneous"[TIAB] AND "lymph"[TIAB] AND "node"[TIAB] AND "syndrome"[TIAB]) OR "mucocutaneous lymph node syndrome"[TIAB] OR ("kawasaki"[TIAB] AND "disease"[TIAB]) OR "kawasaki disease"[TIAB]) OR ("mucocutaneous lymph node syndrome"[MeSH Terms] OR ("mucocutaneous"[TIAB] AND "lymph"[TIAB] AND "node"[TIAB] AND "syndrome"[TIAB]) OR "mucocutaneous lymph node syndrome"[TIAB] OR ("kawasaki"[TIAB] AND "syndrome"[TIAB]) OR "kawasaki syndrome"[TIAB])) AND ("infant"[MeSH Terms] OR "child"[MeSH Terms] OR "adolescent"[MeSH Terms] OR "Pediatrics"[Mesh] OR Pediatric[TIAB] OR Pediatrics[TIAB] OR Paediatric[TIAB] OR Paediat-

rics[TIAB] OR children[TIAB] OR adolescent[TIAB] OR Teenager[TIAB] OR Youths[TIAB] OR Youth[TIAB]) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 34 publications were found. Search field settings of (cardiac OR 'heart'/exp OR heart) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('angiocardiography'/exp OR angiography OR 'catheterization'/exp OR 'catheterization') AND ('mucocutaneous lymph node syndrome'/exp OR 'mucocutaneous lymph node syndrome' OR kawasaki) AND (infant OR child OR adolescent OR Pediatrics OR Pediatric OR Pediatrics OR Paediatric OR Paediatrics OR children OR adolescent OR Teenager OR Youths OR Youth) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim) AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) were used to search the Embase database and 33 publications were found. Of these, 7 related publications were reviewed.

Scenario 8: Detection of CAD: Asymptomatic

For the PubMed database, (cardiac OR coronary angiography) AND (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND ("Asymptomatic Diseases"[Mesh] OR asymptomat*) AND (CHD OR coronary Heart Disease OR coronary artery disease OR CAD) AND (risk factors OR framingham risk score OR framingham OR risk) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang]) AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 90 publications were found. Search field settings of (cardiac OR 'heart'/exp OR heart OR 'angiocardiography'/exp OR (coronary AND angiograph*)) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('asymptomatic disease'/exp OR asymptomat*) AND ('coronary artery disease'/exp OR (coronary artery diseas*) OR CAD OR 'congenital heart disease'/exp OR (Coronary Heart Disease) OR CHD) AND (risk factor* OR framingham risk score OR framingham OR risk) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim) AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) were used to search the Embase database and 108 publications were found. Of these, 1 related systematic review article was reviewed.

Scenario 9: Detection of myocardial scar and viability in ischemic heart disease

(1) To determine the location and extent of myocardial necrosis including 'no reflow' regions/ Post-acute myocardial infarction

For the PubMed database, cardiac AND (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (post OR after) AND acute AND ("Myocardial Infarction"[Mesh] OR Myocardial Infarction OR myocardial necrosis) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND

([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 104 RCTs, 2 meta-analysis, and 4 systemic reviews were found. Search field settings of (cardiac OR 'heart'/exp OR heart) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND (Post OR after) AND ('acute heart infarction'/exp OR (acute Myocardial Infarction) OR (acute myocardial necrosis)) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) were used to search the Embase database and 16 RCTs, 6 meta-analysis, and 3 systematic reviews were found. Of these, 4 related publications were reviewed.

(2) To determine the location and extent of myocardial necrosis including 'no reflow' regions/ Post-acute myocardial infarction

For the PubMed database, cardiac AND (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (Post[All Fields] OR after[All] OR ("postoperative period"[MeSH Terms] OR ("postoperative"[All Fields] AND "period"[All Fields]) OR "postoperative period"[All Fields] OR "postoperative"[All Fields])) AND ((percutaneous[TIAB] AND ("heart"[MeSH Terms] OR "heart"[TIAB] OR "coronary"[TIAB]) AND intervention[TIAB]) OR stent[TIAB] OR "Stents"[Mesh] OR "percutaneous coronary intervention"[MeSH Terms]) AND ("Myocardial Infarction"[Mesh] OR Myocardial Infarction OR myocardial necrosis) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 94 RCTs and 1 systematic review were found. Search field settings of (cardiac OR 'heart'/exp OR heart) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('postoperative period'/exp OR post OR after) AND ((percutaneous AND ('heart'/exp OR heart OR coronary) AND intervention) OR 'percutaneous coronary intervention'/exp OR 'stent'/exp OR stent OR Stents) AND ('heart infarction'/exp OR (Myocardial Infarction) OR (myocardial necrosis)) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim) AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) were used to search the Embase database and 19 RCTs, 5 meta-analysis, and 2 systemic reviews were found. Of these, 3 related publications were reviewed.

(3) To determine the location and extent of myocardial necrosis including 'no reflow' regions/ Post-acute myocardial infarction

For the PubMed database, cardiac AND (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND ("Myocardial Revascularization"[Mesh] OR revascularization OR coronary artery bypass OR CABG OR bypass OR stent OR "Stents"[Mesh] OR percutaneous coronary intervention OR PCI) AND (myocardial AND (function OR recovery OR viability)) AND ("2000/01/01"[PDAT] :

"2013/06/31"[PDAT]) AND English[lang] AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 121 RCTs, 3 meta-analysis, and, 9 systemic reviews were found. Search field settings of (cardiac OR 'heart'/exp OR heart) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('heart muscle revascularization'/exp OR revascularization OR (percutaneous AND ('heart'/exp OR heart OR coronary) AND intervention) OR 'percutaneous coronary intervention'/exp OR 'stent'/exp OR stent OR Stents OR 'coronary artery bypass graft'/exp OR GABG OR bypass) AND ((myocardial OR myocardium) AND (function OR recovery OR viability)) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim) AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) were used to search the Embase database and 25 RCTs, 7 meta-analysis, and 5 systemic reviews were found. Of these, 5 related publications were reviewed.

(4) To determine the location and extent of myocardial necrosis including 'no reflow' regions/ Post-acute myocardial infarction

For the PubMed database, cardiac AND (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (SPECT OR single-photon emission-computed tomography OR dobutamine OR stress test OR stress) AND (viability OR Scar OR assessment) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang]) AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 21 RCTs, 3 meta-analysis, and 27 systemic reviews were found. Search field settings of (cardiac OR 'heart'/exp OR heart) AND ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('single photon emission computer tomography'/exp OR spect OR ('single photon' AND 'emission computed' AND tomography) OR 'stress test' OR stress OR dobutamine) AND (viability OR Scar OR assessment) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim) OR [randomized controlled trial]/lim OR [systematic review]/lim) were used to search the Embase database and 7 RCTs, 6 meta-analysis, and 9 systemic reviews were found. Of these, 3 related publications were reviewed.

2. Structure and Myocardial Functional Evaluation in Patients with Risk of Heart Failure or Overt Heart Failure

Scenario 10: Evaluation in patients with risk of heart failure or overt heart failure (general)

(1) Evaluation of LV function

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND Coronary angiography AND ("ventricular function, left"[MeSH Terms] OR "Ventricular Dysfunction, Left"[Mesh] OR "Hypertrophy, Left Ventricular"[Mesh] OR left ventricular function OR LV function) AND (heart failure OR myocardial infarction) AND ("2000/01/01"[PDAT] :

"2013/06/31"[PDAT]) AND English[lang] AND Randomized Controlled Trial[ptyp] was used to filter publication searches and 36 publications were found. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 74 publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('angiocardiography'/exp OR Coronary angiograph*) AND ('heart left ventricle function'/exp OR 'heart left ventricle failure'/exp OR 'heart left ventricle hypertrophy'/exp OR left ventricular function OR LV function) AND ('heart failure'/exp AND 'heart infarction'/exp OR heart failure OR myocardial infarction) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [randomized controlled trial]/lim were used to search the Embase database and 6 publications were found. Additionally, settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('angiocardiography'/exp OR Coronary angiograph*) AND ('heart left ventricle function'/exp OR 'heart left ventricle failure'/exp OR 'heart left ventricle hypertrophy'/exp OR left ventricular function OR LV function) AND ('heart failure'/exp AND 'heart infarction'/exp OR heart failure OR myocardial infarction) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim [systematic review]/lim were used and 1 publication was found. Of these, 9 related publications were reviewed.

(2) Etiology evaluation

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND Coronary angiography AND (new OR onset OR newly OR first OR potential OR suspected OR suspect) AND Heart failure AND ("2000/01/01"[PDAT]: "2013/06/31"[PDAT]) AND English[lang] was used to filter publication searches and 90 publications were found. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 48 publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('angiocardiography'/exp OR Coronary angiograph*) AND (new* OR onset OR newly OR first OR potential OR suspected OR suspect*) AND ('heart failure'/exp OR heart failure) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [randomized controlled trial]/lim were used to search the Embase database and 4 publications were found. Additional settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('angiocardiography'/exp OR Coronary angiograph*) AND (new* OR onset OR newly OR first OR potential OR suspected OR suspect*) AND ('heart failure'/exp OR heart failure) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [meta analysis]/lim displayed 2 publications and setting of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('angiocardiography'/exp OR Coronary angiograph*) AND (new* OR onset OR newly OR first OR potential OR suspected OR suspect*) AND ('heart failure'/exp OR heart failure) AND ([english]/lim AND [hu-

mans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [systematic review]/lim found 4 publications. Of these, 8 related publications were reviewed.

(3) ICD candidacy

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND ("Defibrillators, Implantable"[Mesh] OR Implantable Defibrillators OR Implantable Defibrillator) AND (cardioverter OR cardio OR cardiac OR heart) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Randomized Controlled Trial[ptyp] was used to filter publication searches and 3 publications were found. Additionally, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND ("Defibrillators, Implantable"[Mesh] OR Implantable Defibrillators OR Implantable Defibrillator) AND (cardioverter OR cardio OR cardiac OR heart) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND systematic[sb] was used and 5 publications were found. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 52 publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('implantable cardioverter defibrillator'/exp OR ((Implantable Defibrillators OR Implantable Defibrillator) AND (cardioverter OR cardio OR cardiac OR 'heart'/exp OR heart))) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim were used to search the Embase database and 219 publications were found. Of these, 9 related publications were reviewed.

(4) CRT candidacy or planning

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND cardiac resynchronization therapy AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Randomized Controlled Trial[ptyp] was used to filter publication searches and 9 publications were found.

Additionally, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND cardiac resynchronization therapy AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Meta-Analysis[ptyp] was used and 1 publication was found. (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND cardiac resynchronization therapy AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND systematic[sb] displayed 6 publications. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 45publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('cardiac resynchronization therapy'/exp OR cardiac resynchronization therapy) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim were used to search the Embase database and 275 publications were found. Of these, 7 related publications were reviewed.

Scenario 11: Patients with congenital heart disease

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND Congenital Heart Disease AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang]

AND Randomized Controlled Trial[ptyp] was used to filter publication searches and 6 publications were found. Additionally (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND Congenital Heart Disease AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND systematic[sb] was used and 17 publications were found. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 67 publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('congenital heart disease'/exp OR Congenital Heart Disease) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [randomized controlled trial]/lim were used to search the Embase database and 4 publications were found. Additionally, ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('congenital heart disease'/exp OR Congenital Heart Disease) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [meta analysis]/lim were used and 10 publications were found. Settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('congenital heart disease'/exp OR Congenital Heart Disease) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [systematic review]/lim displayed 12 publications. Of these, 9 related publications were reviewed.

Scenario 12: Patients with valvular heart disease

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND ("Heart Valve Diseases"[Mesh] OR Heart Valve Diseases OR Heart Valve Disease OR Valvular Heart Disease OR Valvular Heart Disease) AND ("Echocardiography"[Mesh] OR echocardiogram OR Echocardiography OR "Echocardiography, Transesophageal"[Mesh] OR transesophageal echocardiography OR TEE) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Randomized Controlled Trial[ptyp] was used to filter publication searches and 33 publications were found. When (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND ("Heart Valve Diseases"[Mesh] OR Heart Valve Diseases OR Heart Valve Disease OR Valvular Heart Disease OR Valvular Heart Disease) AND ("Echocardiography"[Mesh] OR echocardiogram OR Echocardiography OR "Echocardiography, Transesophageal"[Mesh] OR transesophageal echocardiography OR TEE) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Meta-Analysis[ptyp] was used, 1 publication was found. Additionally, settings of (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND ("Heart Valve Diseases"[Mesh] OR Heart Valve Diseases OR Heart Valve Disease OR Valvular Heart Disease OR Valvular Heart Disease) AND ("Echocardiography"[Mesh] OR echocardiogram OR Echocardiography OR "Echocardiography, Transesophageal"[Mesh] OR transesophageal echocardiography OR TEE) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND systematic[sb] displayed 26 publications. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used

to find 69 publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('valvular heart disease'/exp OR Heart Valve Diseases OR Heart Valve Disease OR Valvular Heart Diseases OR Valvular Heart Disease) AND ('echocardiography'/exp OR echocardiogram OR Echocardiograp* OR 'transesophageal echocardiography'/exp OR transesophageal echocardiograp* OR TEE) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [randomized controlled trial]/lim were used to search the Embase database and 10 publications were found. Settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('valvular heart disease'/exp OR Heart Valve Diseases OR Heart Valve Disease OR Valvular Heart Diseases OR Valvular Heart Disease) AND ('echocardiography'/exp OR echocardiogram OR Echocardiograp* OR 'transesophageal echocardiography'/exp OR transesophageal echocardiograp* OR TEE) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [meta analysis]/lim displayed 4 publications, and settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('valvular heart disease'/exp OR Heart Valve Diseases OR Heart Valve Disease OR Valvular Heart Diseases OR Valvular Heart Disease) AND ('echocardiography'/exp OR echocardiogram OR Echocardiograp* OR 'transesophageal echocardiography'/exp OR transesophageal echocardiograp* OR TEE) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [systematic review]/lim displayed 7 publications. Of these, 5 related publications were reviewed.

Scenario 13: Patients with suspected or diagnosed myocardial disease

(1) ARVC or ventricular arrhythmia

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (arrhythmogenic right ventricular cardiomyopathy OR ARVC OR syncope OR ventricular arrhythmia) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Randomized Controlled Trial[ptyp] was used to filter publication searches and 13 publications were found. Additionally, settings of (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (arrhythmogenic right ventricular cardiomyopathy OR ARVC OR syncope OR ventricular arrhythmia) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Meta-Analysis[ptyp] displayed 2 publications and settings of (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (arrhythmogenic right ventricular cardiomyopathy OR ARVC OR syncope OR ventricular arrhythmia) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND systematic[sb] displayed 19 publications. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 121 publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('heart right ventricle dysplasia'/exp OR arrhythmogenic right ventricular cardiomyopathy OR ARVC OR syncope OR ventricular arrhythmia) AND ([eng-

lish]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [randomized controlled trial]/lim were used to search the Embase database and 9 publications were found. Additionally, settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('heart right ventricle dysplasia'/exp OR arrhythmogenic right ventricular cardiomyopathy OR ARVC OR syncope OR ventricular arrhythmia) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [meta analysis]/lim displayed 4 publications, and settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('heart right ventricle dysplasia'/exp OR arrhythmogenic right ventricular cardiomyopathy OR ARVC OR syncope OR ventricular arrhythmia) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [systematic review]/lim displayed 9 publications. Of these, 4 related publications were reviewed.

(2) Myocarditis or MI with normal coronary

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (myocarditis OR myocardial infarction) AND (coronary arteries OR coronary artery OR cardiac enzymes OR cardiac enzyme) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Randomized Controlled Trial[ptyp] was used to filter publication searches and 93 publications were found. Settings of (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (myocarditis OR myocardial infarction) AND (coronary arteries OR coronary artery OR cardiac enzymes OR cardiac enzyme) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Meta-Analysis[ptyp] displayed 3 and settings of (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (myocarditis OR myocardial infarction) AND (coronary arteries OR coronary artery OR cardiac enzymes OR cardiac enzyme) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND systematic[sb] displayed 15 publications. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 111 publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('myocarditis'/exp OR myocarditis OR 'heart infarction'/exp OR myocardial infarction) AND ('coronary blood vessel'/exp OR coronary arter* OR cardiac enzym*) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [randomized controlled trial]/lim were used to search the Embase database and 12 publications were found. Additionally, settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('myocarditis'/exp OR myocarditis OR 'heart infarction'/exp OR myocardial infarction) AND ('coronary blood vessel'/exp OR coronary arter* OR cardiac enzym*) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [meta analysis]/lim displayed 5 and settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('myocarditis'/exp OR myocarditis OR 'heart in-

farction'/exp OR myocardial infarction) AND ('coronary blood vessel'/exp OR coronary arter* OR cardiac enzym*) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [systematic review]/lim displayed 7 publications. Of these, 7 related publications were reviewed.

(3) Specific cardiomyopathy

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (cardiomyopathies OR cardiomyopathy) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Randomized Controlled Trial[ptyp] was used to filter publication searches and 47 publications were found. Additionally, settings of (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (cardiomyopathies OR cardiomyopathy) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Meta-Analysis[ptyp] displayed 4 and settings of (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (cardiomyopathies OR cardiomyopathy) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND systematic[sb] displayed 32 publications. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 93 publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('cardiomyopathy'/exp OR cardiomyopathies OR cardiomyopathy) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [randomized controlled trial]/lim were used to search the Embase database and 5 publications were found. Additionally, setting of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('cardiomyopathy'/exp OR cardiomyopathies OR cardiomyopathy) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [meta analysis]/lim displayed 11 and settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('cardiomyopathy'/exp OR cardiomyopathies OR cardiomyopathy) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [systematic review]/lim diaplayed 15 publications. Of these, 14 related publications were reviewed.

Scenario 14: Evaluation in patients with HCM

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (hypertrophic cardiomyopathies OR hypertrophic cardiomyopathy OR hypertrophy cardiomyopathy OR hypertrophy cardiomyopathies) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Randomized Controlled Trial[ptyp] was used to filter publication searches and 9 publications were found.

Additionally, settings of (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (hypertrophic cardiomyopathies OR hypertrophic cardiomyopathy OR hypertrophy cardiomyopathy OR hypertrophy cardiomyopathies) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND Meta-Analysis[ptyp] AND (Magnetic Resonance Imaging OR magnetic reso-

nance OR MR OR MRI) AND (hypertrophic cardiomyopathies OR hypertrophic cardiomyopathy OR hypertrophy cardiomyopathy OR hypertrophy cardiomyopathies) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND systematic[sb] displayed 9 publications. In the Cochrane Library database, the same MeSH descriptors used in the PubMed database were used to find 30 publications. Search field settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('hypertrophic cardiomyopathy'/exp OR (hypertroph* AND cardiomyopath*)) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [meta analysis]/lim were used to search the Embase database and 6 publications were found. Additionally, settings of ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('hypertrophic cardiomyopathy'/exp OR (hypertroph* AND cardiomyopath*)) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim AND [systematic review]/lim displayed 4 publications. Of these, 14 related publications were reviewed.

3. Miscellaneous disease

Scenario 15: Evaluation of cardiac mass (suspected tumor or thrombus)

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND cardiac mass AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 125 RCTs, 3 meta-analysis, and 24 systematic reviews were found. For the EmBase database, ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND cardiac mass AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 13 RCTs, 13 meta-analysis, and 11 systematic reviews were found. Of these, 9 related publications were reviewed.

Scenario 16: Evaluation of pericardium

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (pericardium OR pericarditis OR pericardial) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang]) AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 8 RCTs and 4 systematic reviews were found. For the Embase database, ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('pericardium'/exp OR 'pericarditis'/exp OR pericardium OR pericarditis OR pericardial) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 3 RCTs, 2 meta-analysis, and 5 systematic reviews were found. Of these, 5 related publications were reviewed.

Scenario 17: Evaluation of aortic dissection

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND aortic dissection AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang] AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 4 RCTs, 1 meta-analysis, and 13 systematic reviews were found. For the EmBase database, ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('aorta dissection'/exp OR ((aortic OR aorta) AND dissection)) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 1 RCT, 4 meta-analysis, and 3 systematic reviews were found. Of these, 6 related publications were reviewed.

Scenario 18: Evaluation of pulmonary veins prior to radiofrequency ablation for atrial fibrillation/ Left atrial and pulmonary venous anatomy including dimensions of veins for mapping purposes

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (pulmonary veins OR pulmonary vein OR pulmonary venous) AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang]) AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 24 RCTs, 5 meta-analysis, and 13 systematic reviews were found. For the EmBase database, ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('pulmonary vein'/exp OR 'pulmonary veins' OR 'pulmonary vein' OR 'pulmonary venous') AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim) OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 2 RCTs, 2 meta-analysis, and 1 systematic review were found. Of these, 5 related publications were reviewed.

Scenario 19: Anatomic assessment before percutaneous device closure of ASD or VSD/Anatomic assessment before percutaneous aortic valve replacement

For the PubMed database, (Magnetic Resonance Imaging OR magnetic resonance OR MR OR MRI) AND (ASD OR Atrial Septal Defect OR VSD OR Ventricular Septal Defect OR percutaneous aortic valve replacement) NOT autism spectrum disorder AND ("2000/01/01"[PDAT] : "2013/06/31"[PDAT]) AND English[lang]) AND ([cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 9 RCTs, 1 meta-analysis, and 7 systematic reviews were found. For the EmBase database, ('nuclear magnetic resonance'/exp OR (magnetic AND resonance AND imaging) OR (magnetic AND resonance) OR mr OR mri) AND ('heart atrium septum defect'/exp OR ASD OR (Atrial Septal Defect) OR 'heart ventricle septum defect'/exp OR VSD OR (Ventricular Septal Defect) OR 'transcatheter aortic valve implantation'/exp OR (percutaneous aortic valve replacement)) NOT

(autism AND spectrum AND disorder) AND ([english]/lim AND [humans]/lim AND [2000-2013]/py) NOT [medline]/lim) OR [randomized controlled trial]/lim OR [systematic review]/lim) was used to filter publication searches and 4 meta-analysis and 1 systematic review were found. Of these, 5 related publications were reviewed.

8. Level of Evidence of the References

Question	Reference	Study type	Patients	Purpose of Study	Study Results	Level of Study
Q1-4	Lipinski MJ, McVey CM, Berger JS, Kramer CM, Salerno M. Prognostic Value of Stress Cardiac Magnetic Resonance Imaging in Patients with Known or Suspected Coronary Artery Disease: A Systematic Review and Meta-Analysis. J Am Coll Cardiol 2013;62(9):826-838	Meta-Analysis	11636 patients (19 studies)	We performed systematic review and meta-analysis to understand the role of stress CMR in assessing cardiovascular prognosis in patients with known or suspected CAD.	Nineteen studies (14 vasodilator, 4 dobutamine, and 1 that used both) had a total of 11,636 patients and a mean follow-up of 32 months. Patients had a mean age of 63 +/- 12 years, 63% were male, 26% with prior MI, LV ejection fraction of 61 +/- 12%, late gadolinium enhancement (LGE) in 29%, and ischemia in 32%. Patients with ischemia had a higher incidence of MI (OR 7.7, p<0.0001), cardiovascular death (OR 7.0, p<0.0001), and the combined endpoint (OR 6.5, p<0.0001) as compared with those with a negative study. The combined outcome annualized events rates were 4.9% for a positive versus 0.8% for negative stress CMR (p<0.0001), 2.8% versus 0.3% for cardiovascular death (p<0.0001), and 2.6% versus 0.4% for MI (p<0.0005). The presence of LGE also was significantly associated with worse prognosis. CONCLUSION: A negative stress CMR study is associated with very low risk of cardiovascular death and myocardial infarction. Stress CMR has excellent prognostic characteristics and may help guide risk stratification of patients with known or suspected CAD.	1

Q1-4, Q10, 11	Greenwood, J. P., et al. Cardiovascular magnetic resonance and single-photon emission computed tomography for diagnosis of coronary heart disease (CE-MARC): a prospective trial. Lancet 2012; 379(9814):453-460	Randomized trial	752 patients	The aim of this study was to establish the diagnostic accuracy of a multiparametric cardiovascular magnetic resonance (CMR) protocol with x-ray coronary angiography as the reference standard, and to compare CMR with SPECT, in patients with suspected coronary heart disease.	In the 752 recruited patients, 39% had significant CHD as identified by x-ray angiography. For multiparametric CMR the sensitivity was 86.5% (95% CI 81.8-90.1), specificity 83.4% (79.5-86.7), positive predictive value 77.2%, (72.1-81.6) and negative predictive value 90.5% (87.1-93.0). The sensitivity of SPECT was 66.5% (95% CI 60.4-72.1), specificity 82.6% (78.5-86.1), positive predictive value 71.4% (65.3-76.9), and negative predictive value 79.1% (74.8-82.8). The sensitivity and negative predictive value of CMR and SPECT differed significantly ($p<0.0001$ for both) but specificity and positive predictive value did not ($p=0.916$ and $p=0.061$, respectively). INTERPRETATION: CE-MARC is the largest, prospective, real world evaluation of CMR and has established CMR's high diagnostic accuracy in coronary heart disease and CMR's superiority over SPECT. It should be adopted more widely than at present for the investigation of coronary heart disease.	2
Q1-4, Q10, 11	Jaarsma, C., et al. Diagnostic performance of noninvasive myocardial perfusion imaging using single-photon emission computed tomography, cardiac magnetic resonance, and positron emis-	Meta-Analysis	32 articles (CMR) 114 articles (SPECT) 15 articles (PET)	This study aimed to determine the diagnostic accuracy of the 3 most commonly used noninvasive myocardial perfusion imaging modalities, single-photon emission computed tomography	RESULTS: Of the 3,635 citations, 166 articles (n = 17,901) met the inclusion criteria: 114 SPECT, 37 CMR, and 15 PET articles. There were not enough publications on other perfusion techniques such as perfusion echocardiography and computed tomography to include these modalities into the study. The patient-based analysis per imaging modality demonstrated a pooled sensitivity of 88% (95% confidence interval [CI]: 88% to 89%), 89%	1

	sion tomography imaging for the detection of obstructive coronary artery disease: a meta-analysis. J Am Coll Cardiol 2012;59(19):1719-1728			(SPECT), cardiac magnetic resonance (CMR), and positron emission tomography (PET) perfusion imaging for the diagnosis of obstructive coronary artery disease (CAD). Additionally, the effect of test and study characteristics was explored.	(95% CI: 88% to 91%), and 84% (95% CI: 81% to 87%) for SPECT, CMR, and PET, respectively; with a pooled specificity of 61% (95% CI: 59% to 62%), 76% (95% CI: 73% to 78%), and 81% (95% CI: 74% to 87%). This resulted in a pooled diagnostic odds ratio (DOR) of 15.31 (95% CI: 12.66 to 18.52; I(2) 63.6%), 26.42 (95% CI: 17.69 to 39.47; I(2) 58.3%), and 36.47 (95% CI: 21.48 to 61.92; I(2) 0%). Most of the evaluated test and study characteristics did not affect the ranking of diagnostic performances. CONCLUSIONS: SPECT, CMR, and PET all yielded a high sensitivity, while a broad range of specificity was observed. SPECT is widely available and most extensively validated; PET achieved the highest diagnostic performance; CMR may provide an alternative without ionizing radiation and a similar diagnostic accuracy as PET. We suggest that referring physicians consider these findings in the context of local expertise and infrastructure.	
Q1-4	Schuetz, G. M., et al. Meta-analysis: noninvasive coronary angiography using computed tomography versus magnetic resonance imaging. Ann Intern Med 2010;152(3): 167-177	Meta-Analysis	20 articles (MRA) 89 articles (CTA)	To compare CT and MRI for ruling out clinically significant coronary artery disease (CAD) in adults with suspected or known CAD.	DATA SYNTHESIS: 89 and 20 studies (comprising 7516 and 989 patients) assessed CT and MRI, respectively. Bivariate analysis of data yielded a mean sensitivity and specificity of 97.2% (95% CI, 96.2% to 98.0%) and 87.4% (CI, 84.5% to 89.8%) for CT and 87.1% (CI, 83.0% to 90.3%) and 70.3% (CI, 58.8% to 79.7%) for MRI. In studies that included only patients with suspected CAD, sensitivity and specificity of CT were 97.6% (CI, 96.1% to 98.5%) and 89.2% (CI, 86.0% to 91.8%). Covariate analysis yield-	1

					ed a significantly higher sensitivity for CT scanners with more than 16 rows (98.1% [CI, 97.0% to 99.0%]; P < 0.050) than for older-generation scanners (95.6% [CI, 94.0% to 97.0%]). Heart rates less than 60 beats/min during CT yielded significantly better values for sensitivity than did higher heart rates (P < 0.001). LIMITATIONS: Few studies investigated coronary angiography with MRI. Only 5 studies were direct head-to-head comparisons of CT and MRI. Covariate analyses explained only part of the observed heterogeneity. CONCLUSION: For ruling out CAD, CT is more accurate than MRI. Scanners with more than 16 rows improve sensitivity, as do slowed heart rates.	
Q5	Casolo, G., et al. Detection and assessment of coronary artery anomalies by three-dimensional magnetic resonance coronary angiography. Int J Cardiol 2005;103(3):317-322	Non-consecutive studies	336	Coronary artery anomalies (CAAs) are a relatively rare condition usually diagnosed in vivo by conventional angiography. In the past few years Magnetic resonance coronary angiography (MRCA) has been used to detect CAAs and found to be highly accurate. No data is available regarding the ability of MRCA to detect previous-	Nineteen patients with CAAs (12 men, 7 women; mean age, 53+/-18 years) were identified by MRCA. Six out of the 19 CAAs subjects had already been detected by other means (coronary angiography in 5, and transesophageal echocardiography in 1 case). However in none of them a complete anatomical assessment was achieved. In 13 patients CAAs were an unexpected and new finding. MRCA was able to assess the origin and proximal course of the anomalous artery in all the cases. CONCLUSIONS: MRCA is able to detect the presence and anomalous course of CAAs. Besides offering precise information about already suspected CAAs, MRCA can identify anomalies previously not suspected. This study suggests a po-	3

				ly not suspected anomalies.	tential role for MRCA as a screening tool for CAAs in young patients with angina, ventricular arrhythmias, or unexplained syncope as well as in highly competitive athletes.	
Q5	Clemente, A., et al. Anomalous origin of the coronary arteries in children: diagnostic role of three-dimensional coronary MR angiography. Clin Imaging 2010;34(5):337-343	Non-consecutive studies	15	We tested the diagnostic potential of CMRA angiography in a prospective study on AOCA in young patients.	AOCA was confirmed by 3D-CMRA in 8 out of 15 cases (53%) and three different anatomical variants were demonstrated, that is, ectopic origin of the left circumflex artery arising from the right coronary artery with retroaortic course in four cases, single coronary artery arising from the right sinus of Valsalva with interarterial course in one case, ectopic right coronary artery arising from the left sinus of Valsalva with interarterial course in one case; in two patients without anomalies of origin of the coronary arteries, elongated LMCA with angulation of the proximal segment of the left circumflex artery was present. When AOCA is suspected particularly in children (especially athletes), CMRA without the use of contrast medium is an effective diagnostic technique, which is useful to clarify the spatial position of the anomalous course of the main coronary branches in order to suggest the most convenient management of the disease. CMRA does not need contrast medium, needles, and beta-blockers; is repeatable in the same examination without the exposure to X-rays; allows a parent to stay near the child; and needs low collaboration in low-stress conditions.	3

Q6-Q9	Plein, S., et al. Assessment of non-ST-segment elevation acute coronary syndromes with cardiac magnetic resonance imaging. J Am Coll Cardiol 2004;44(11):2173-2181	Follow-up study of non-randomized controlled cohort	68	The goal of this study was to determine: 1) if the presence of significant coronary stenosis in patients presenting with non-ST-segment elevation acute coronary syndromes (NSTE-ACS) can be predicted by cardiac magnetic resonance (CMR) imaging; and 2) if the analysis of several CMR methods improves its diagnostic yield compared with analysis of individual methods.	RESULTS: Comprehensive CMR analysis yielded a sensitivity of 96% and a specificity of 83% to predict the presence of significant coronary stenosis and was more accurate than analysis of any individual CMR method; CMR was significantly more sensitive and accurate than the Thrombolysis In Myocardial Infarction risk score ($p < 0.001$). CONCLUSIONS: Cardiac magnetic resonance imaging accurately predicts the presence of significant CAD in patients with NSTE-ACS. In this study, a comprehensive analysis of several CMR methods improved the accuracy of the test.	3
Q6-Q9	Miller, C. D., et al. Stress CMR imaging observation unit in the emergency department reduces 1-year medical care costs in patients with acute chest pain: a randomized study for comparison with inpatient care. JACC Cardiovasc Imaging 2011;4(8): 862-870	Randomized trial	109	This study sought to compare the direct cost of medical care and clinical events during the first year after patients with intermediate risk acute chest pain were randomized to stress cardiac magnetic resonance (CMR) observation unit (OU) testing versus inpa-	RESULTS: We included 109 randomized subjects in this analysis (52 OU-CMR, 57 inpatient care). The median age was 56 years; baseline characteristics were similar in both groups. At 1 year, 6% of OU-CMR and 9% of inpatient care participants experienced a major cardiac event ($p = 0.72$) with 1 patient in each group experiencing a cardiac event after discharge. First-year cardiac-related costs were significantly lower for participants randomized to OU-CMR than for participants receiving inpatient care (geometric mean = $3,101 vs. $4,742 including the index visit [$p = 0.004$] and $29 vs. $152 following discharge [p	2

				tient care.	= 0.012]). During the year following randomization, 6% of OU-CMR and 9% of inpatient care participants experienced a major cardiac event (p = 0.72). CONCLUSIONS: An OU-CMR strategy reduces cardiac-related costs of medical care during the index visit and over the first year subsequent to discharge, without an observed increase in major cardiac events.	
Q6-Q9	Miller, C. D., et al. Stress CMR Reduces Revascularization, Hospital Readmission, and Recurrent Cardiac Testing in Intermediate-Risk Patients With Acute Chest Pain. JACC Cardiovasc Imaging 2013; 6(7):785-794	Randomized trial	105	The aim of this study was to determine the effect of stress cardiac magnetic resonance (CMR) imaging in an observation unit (OU) on revascularization, hospital readmission, and recurrent cardiac testing in intermediate-risk patients with possible acute coronary syndromes (ACS).	RESULTS: The median age of participants was 56 years (range 35 to 91 years), 54% were men, and 20% had pre-existing coronary disease. Index hospital admission was avoided in 85% of the OU CMR participants. The primary outcome occurred in 20 usual care participants (38%) versus 7 OU CMR participants (13%) (hazard ratio: 3.4; 95% confidence interval: 1.4 to 8.0, p = 0.006). The OU CMR group experienced significant reductions in all components: revascularizations (15% vs. 2%, p = 0.03), hospital readmissions (23% vs. 8%, p = 0.03), and recurrent cardiac testing (17% vs. 4%, p = 0.03). Median length of stay was 26 h (interquartile range: 23 to 45 h) in the usual care group and 21 h (interquartile range: 15 to 25 h) in the OU CMR group (p < 0.001). ACS after discharge occurred in 3 usual care participants (6%) and no OU CMR participants. CONCLUSIONS: In this single-center trial, management of intermediate-risk patients with possible ACS in an OU with stress CMR reduced coronary artery revascularization, hospital readmissions,	2

					and recurrent cardiac testing, without an increase in post-discharge ACS at 90 days.	
Q10, 11	Schwitter, J., et al. Superior diagnostic performance of perfusion-cardiovascular magnetic resonance versus SPECT to detect coronary artery disease: The secondary endpoints of the multicenter multivendor MR-IMPACT II (Magnetic Resonance Imaging for Myocardial Perfusion Assessment in Coronary Artery Disease Trial). J Cardiovasc Magn Reson 2012;14:61	Randomized trial	533	Perfusion-cardiovascular magnetic resonance (CMR) is generally accepted as an alternative to SPECT to assess myocardial ischemia non-invasively. However its performance vs gated-SPECT and in sub-populations is not fully established.	RESULTS: The diagnostic performance (= area under ROC = AUC) of CMR was superior to SPECT (p = 0.0004, n = 425) and to gated-SPECT (p = 0.018, n = 253). CMR performed better than SPECT in MVD (p = 0.003 vs all SPECT, p = 0.04 vs gated-SPECT), in men (p = 0.004, n = 313) and in women (p = 0.03, n = 112) as well as in the non-infarct patients (p = 0.005, n = 186 in 1-3 vessel disease and p = 0.015, n = 140 in MVD). CONCLUSION: In this large multicenter, multivendor study the diagnostic performance of perfusion-CMR to detect CAD was superior to perfusion SPECT in the entire population and in sub-groups. Perfusion-CMR can be recommended as an alternative for SPECT imaging. TRIAL REGISTRATION: ClinicalTrials.gov, Identifier: NCT00977093.	2
Q12	Groothuis, J. G., et al. Combined non-invasive functional and anatomical diagnostic work-up in clinical practice: the magnetic resonance and computed tomography in suspected coronary artery disease (MARCC) study.	Follow-up study of non-randomized controlled coho studies without consistently applied reference stand-	192	The combined use of cardiac computed tomography (CT) coronary angiography (CTCA) and myocardial perfusion imaging allows the non-invasive evaluation of coronary morphology and function. Cardiovascular magnetic	A total of 192 patients with low or intermediate pre-test probability of CAD underwent CTCA and CMR. All patients with obstructive CAD on CTCA and/or myocardial ischaemia on CMR were referred for invasive coronary angiography (ICA). Fractional flow reserve was measured in case of intermediate lesions (30-70% diameter stenosis) on ICA. Additional cardiac and extra-cardiac findings by CTCA and CMR were registered. The combination of CTCA and CMR significantly improved specificity and	3

	Eur Heart J 2013;34(26): 1990-1998	ards		resonance (CMR) imaging has several advantages: it can simultaneously assess myocardial perfusion, ventricular and valvular function, cardiomyopathy, and aortic disease and does not involve any additional ionizing radiation. We investigated the combined use of cardiac CT and CMR for the diagnostic evaluation of patients with suspected coronary artery disease (CAD) in clinical practice.	overall accuracy (94 and 91%) for the detection of significant CAD compared with their use as a single technique (CTCA 39 and 57%, P < 0.0001; CMR 82 and 83%, P = 0.016). No events were recorded during follow-up (18 +/- 6 months) in 104 patients who did not undergo ICA. Furthermore, the combined strategy provided an alternative diagnosis in 19 patients. CONCLUSION: The combined use of CTCA and CMR significantly improved specificity and overall diagnostic accuracy for the detection of significant CAD and allowed the detection of alternative (extra-)cardiac disease in patients without significant CAD.	
Q13, 15	Langerak, S. E., et al. Detection of vein graft disease using high-resolution magnetic resonance angiography. Circulation 2002;105(3):328-333	Individual cross sectional studies with consistently applied reference standard	38	The purpose of our study was to determine the accuracy of high-resolution navigator-gated 3-dimensional (3-D) MR angiography in detecting vein graft disease.	MR angiography was performed in addition to coronary angiography with quantitative coronary analysis in 56 vein grafts from 38 patients (mean age 66.6+/-9.3 years), who presented with recurrent chest pain after bypass surgery. Eighteen grafts showed a luminal stenosis >/=50%, 11 grafts a stenosis >/=70%, and 6 grafts were occluded. All MR angiograms were evaluated independently by 2 blinded observers, who scored the presence of graft occlusion and graft stenosis >/=50% and >/=70% with a confidence level of 1 to 10. MR image	2

					quality was judged as insufficient in 6 grafts and these were excluded. Receiver-operator characteristic analysis revealed an area under the curve of 0.89 and 0.89 for identifying graft occlusion, 0.81 and 0.87 for stenosis >/=50%, and 0.82 and 0.79 for stenosis >/=70% for the 2 observers, respectively. Interobserver agreement in assessing graft occlusion and stenosis >/=50% and >/=70% was 94% (kappa=0.74, r=0.81), 72% (kappa=0.40, r=0.66), and 82% (kappa=0.53, r=0.72), respectively. CONCLUSIONS: High-resolution navigator-gated 3-D MR angiography allows not only good differentiation between patent and occluded vein grafts but also the assessment of vein graft disease with a fair diagnostic accuracy. This approach offers perspective as a noninvasive diagnostic tool for patients who present with recurrent chest pain after vein graft surgery.	
Q13, 15	Galjee, M. A., et al. Value of magnetic resonance imaging in assessing patency and function of coronary artery bypass grafts. An angiographically controlled study. Circulation 1996;93(4):660-666	non-independent reference standard	47	The objectives of this study were first to investigate whether MR cine GE images, performed in addition to standard SE images, have additional value for the assessment of graft patency and second to assess the graft function by measuring the	The 47 patients had 98 proximal aortotomies, of which 60 were single and 38 sequential grafts. Seventy-three grafts were patent; 25 were occluded. Eighty-four grafts (86%) were eligible for comparison of the results of SE and GE images. Assessment of patency was inconclusive on SE images in 7 grafts (5 occluded by angiography) and on GE images in 7 grafts (2 occluded). A comparison of the results of contrast angiography and SE and GE MR imaging techniques showed that both techniques had a high sensitivity (both 98%) and somewhat lower specifici-	4

				flow pattern and flow rate with MR phase velocity imaging.	ty (85% and 88%, respectively) for graft patency. Combined analysis of the SE and GE images did not improve the accuracy. The strength of the interobserver agreement on GE images was good (kappa = 0.66), whereas on SE images the agreement was moderate (kappa = 0.51). Adequate MR phase velocity profiles were obtained in 62 (85%) of the 73 angiographically patent grafts. Graft flow was characterized by a balanced biphasic forward flow pattern. The volume flow of sequential grafts to 3 regions (136 +/- 106 mL/min) was significantly higher than in single grafts (63 +/- 41 mL/min, P < .01). CONCLUSIONS: Considering the good interobserver agreement and the 85% success rate of quantitative flow measurements, cine GE phase velocity mapping is a promising clinical tool in the noninvasive assessment of graft patency and function.	
Q14, 16	Sardanelli, F., et al. MR evaluation of coronary stents with navigator echo and breath-hold cine gradient-echo techniques. Eur Radiol 2002;12(1):193-200	Individual cross sectional studies with consistently applied reference standard	38	The aim of this study was to evaluate coronary artery stents with MR.	All the stents were recognized as signal void with GE, and all but one with NE. Of the 2 patients with positive EET, the first one, with a stent on the left anterior descending coronary artery, presented low signal distal to the stent at both MR sequences, suggesting dysfunction [60% stenosis at conventional coronary angiography (CCA)]; the second one, with two sequential stents on the right coronary artery, presented lack of signal distal to the stents at both MR sequences, suggesting occlusion (97% stenosis at CCA). For the 44 remaining stents in 36	2

					patients with negative EET, MR high signal before and distal to the stent suggested patency at both sequences. MR seems to be a safe and promising technique for non-invasive evaluation of coronary stents.	
Q14, 16	Duerinckx, A. J., et al. Assessment of coronary artery patency after stent placement using magnetic resonance angiography. J Magn Reson Imaging 1998;8(4):896-902	Case series	16	The ability to noninvasively assess the patency of coronary stents would represent a significant advance. We evaluated the safety and ability of two-dimensional coronary MR angiography in imaging stents and suggesting patency.	Coronary MR angiography was performed with a commercial 1.5-T MR imager using an electrocardiographically gated pulse sequence with breath-holding. Images were obtained in mid-diastole with and without fat suppression. Image artifacts caused by the metal in the stents were clearly visualized in all 26 stents (100% sensitivity for stent detection). Arterial flow signal was seen in the coronary artery or graft distal to the stent in 25 of 26 cases (96%). All patients, except for the one in which distal flow could not be seen, remained symptom free for >2 years. The distribution of stent locations was as follows: 10 in the right coronary artery (RCA), 10 in the left anterior descending coronary artery (LAD), 2 in the left circumflex coronary artery, and 4 in saphenous vein grafts (SVGs) to RCA. One patient had 2 RCA and 2 LAD stents, one had 3 RCA and 1 LAD stents, one had 3 SVG stents, and two had double RCA stents. Coronary MR angiography is safe for noninvasive imaging of coronary stents, and in the proper clinical setting, it can be used to help suggest patency.	4
Q17, 18	Fathala, A. and W. Hassan. Role of multimodality car-	Review			The preoperative cardiac assessment of patients undergoing noncardiac surgery is common in the daily prac-	5

	diac imaging in preoperative cardiovascular evaluation before noncardiac surgery. Ann Card Anaesth 2011;14(2):134-145				tice of medical consultants, anesthesiologists, and surgeons. The number of patients undergoing noncardiac surgery worldwide is increasing. Currently, there are several noninvasive diagnostic tests available for preoperative evaluation. Both nuclear cardiology with myocardial perfusion single photon emission computed tomography (SPECT) and stress echocardiography are well-established techniques for preoperative cardiac evaluation. Recently, some studies demonstrated that both coronary angiography by gated multidetector computed tomography and stress cardiac magnetic resonance might potentially play a role in preoperative evaluation as well, but more studies are needed to assess the role of these new modalities in preoperative risk stratification. A common question that arises in preoperative evaluation is if further preoperative testing is needed, which preoperative test should be used. The preferred stress test is the exercise electrocardiogram (ECG). Stress imaging with exercise or pharmacologic stress agents is to be considered in patients with abnormal rest ECG or patients who are unable to exercise. After reviewing this article, the reader should develop an understanding of the following: (1) the magnitude of the cardiac preoperative morbidity and mortality, (2) how to select a patient for further preoperative testing, (3) currently available noninvasive cardiac testing for the detection of coronary artery disease and	

					assessment of left ventricular function, and (4) an approach to select the most appropriate noninvasive cardiac test, if needed.	
Q20-23	Mavrogeni S, et al. Magnetic resonance angiography is equivalent to x-ray coronary angiography for the evaluation of coronary arteries in kawasaki disease. Journal of the American College of Cardiology 2004;43:649-652	Individual cross sectional studies with consistently applied reference standard	Thirteen patients	The purpose of this study was to compare the results of magnetic resonance angiography(MRA) with X-ray coronary angiography (XCA) in a pediatric population	In six patients, aneurysms of the coronary arteries were identified, while coronary ectasia alone was present in the remaining seven patients. Magnetic resonance angiography and XCA diagnosis of coronary artery aneurysm agreed completely. Maximal aneurysm diameter and length and ectasia diameter by MRA and XCA were similar. No stenotic lesion was identified by either technique.	2
Q20-23	Greil GF, et al. Coronary magnetic resonance angiography in adolescents and young adults with kawasaki disease. Circulation 2002;105:908-911	Individual cross sectional studies with consistently applied reference standard, small number	Six subjects	To evaluate the clinical usefulness of coronary MRA in Kawasaki disease, this study prospectively compared coronary MRA and x-ray coronary angiography findings inpatients with CAAs.	There was complete agreement between MRA and x-ray angiography in the detection of CAA (n=11), coronary artery stenoses (n=2), and coronary occlusions (n=2). Excellent agreement was found between the 2 techniques for detection of CAA maximal diameter (mean difference=0.4±0.6 mm) and length (mean difference=1.4±1.6 mm). The 2 methods showed very similar results for proximal coronary artery diameter (mean Difference=0.2±0.5 mm) and CAA distance from the ostia (mean difference=0.1±1.5 mm).	3
Q20-23	Mavrogeni S, et al. How to image kawasaki disease: A validation of dif-	Review		Kawasaki disease contributes to coronary artery aneurysm in 25% of pa-	Echocardiography is the bedside technique of choice during the acute phase of the disease. MRI can be a valuable tool especially in adolescents, where sometimes	4

	ferent imaging techniques. International journal of cardiology 2008;124:27-31.			tients. Cardiovascular imaging has an important role in diagnosis and follow-up of these cases.	echocardiography fails to detect coronary abnormalities and it has also the advantage of simultaneous perfusion, function and viability evaluation. If MRI is not available, a combination of echocardiography and SPECT gives an overview of anatomy, function and perfusion. MSCT is of limited value for follow-up because of radiation and the misleading data due to coronary calcifications. X-ray coronary angiography is kept mainly for cases where an invasive procedure should be performed.	
Q24-26	Ferket BS, et al. Systematic review of guidelines on imaging of asymptomatic coronary artery disease. Journal of the American College of Cardiology 2011;57:1591-1600	Systematic review	Guidelines in English published between January 1, 2003, and February 26, 2010	The purpose of this study was to critically appraise guidelines on imaging of asymptomatic coronary artery disease (CAD).	Of 2,415 titles identified, 14 guidelines met our inclusion criteria. Eleven of 14 guidelines reported relationship with industry. The AGREE scores varied across guidelines from 21% to 93%. Two guidelines considered cost effectiveness. Eight guidelines recommended against or found insufficient evidence for testing of asymptomatic CAD. The other 6 guidelines recommended imaging patients at intermediate or high CAD risk based on the Framingham risk score, and 5 considered computed tomography calcium scoring useful for this purpose.	1

Q27, 29	Romero J, et al. CMR imaging for the evaluation of myocardial stunning after acute myocardial infarction: A meta-analysis of prospective trials. European heart journal cardiovascular Imaging 2013;14(11):1080-1091	Meta-analysis	17 studies, 634 patients	The aim of the study was to evaluate and compare the sensitivity, specificity, negative predictive value (NPV), and positive predictive value (PPV) of cardiac magnetic resonance imaging (CMR) assessing myocardial stunning after acute myocardial infarction using low-dose dobutamine (LDD), end-diastolic wall thickness, and contrast delayed enhancement (DE).	DE-CMR had a weighted sensitivity of 87% and specificity of 68% to detect myocardial stunning using 50% transmurality as a cut-off, with a PPV and NPV of 83 and 72%, respectively. With an overall diagnostic accuracy of 82%, LDD-CMR had a sensitivity of 67% and a specificity of 81%, with a PPV and NPV of 82 and 63%, respectively. LDD showed an overall accuracy of 74%.	1
Q27	Chan RH, et al. Prognostic utility of late gadolinium enhancement cardiac magnetic resonance imaging in coronary artery disease: A meta-analysis. Journal of Cardiovascular Magnetic Resonance 2013;15:169-170	Meta-analysis	115 full-text articles x subjects	We sought to quantify the risk of major adverse cardiovascular events (MACE) among patients with LGE and CAD.	A total of 4,438 patients were included in the analysis. The overall hazard ratio (HR) for MACE was 2.65 (95% confidence intervals, CI, 1.98-3.56) for the presence of any LGE, with large amounts of heterogeneity between studies (I2, 83.5%). Furthermore, there was a continuous relationship between risk and the amount of LGE detected. For every 10% of the left ventricular mass with LGE, the risk of MACE increased by 56% (HR 1.56/10% LGE, 95% CI 1.39-1.75; I2, 63.6%). Pre-specified meta-regression analyses revealed that the HR for MACE decreased with declining ejection fraction (p=0.02) when	1

					LGE was continuous, and was inversely related to age (p<0.001) when LGE was binary.	
Q28	Selvanayagam JB, et al. Troponin elevation after percutaneous coronary intervention directly represents the extent of irreversible myocardial injury: Insights from cardiovascular magnetic resonance imaging. Circulation 2005;111:1027-1032	Individual cross sectional studies with consistently applied reference standard	Fifty patients	To investigate the quantitative relationship between irreversible injury and cardiac troponin release, we studied the incidence and extent of new irreversible injury in patients undergoing PCI and correlated it to postprocedural changes in cardiac troponin I.	After the procedure, 14 patients (28%) had evidence of new myocardial hyperenhancement, with a mean mass of 6.0±5.8 g, or 5.0±4.8% of total left ventricular mass. All of these patients had raised troponin I levels (range 1.0 to 9.4 μg/L). Thirty-four patients (68%) had no elevated troponin I and no evidence of new myocardial necrosis on MRI. There was a strong correlation between the rise in troponin I measurements at 24 hours and mean mass of new myocardial hyperenhancement, both early (r=0.84; P < 0.001) and late (r=0.71; P < 0.001) after PCI, although there was a trend for a reduction in the size of PCI-induced myocardial injury in the late follow-up scan (P=0.07).	2
Q28	Ricciardi MJ, et al. Visualization of discrete microinfarction after percutaneous coronary intervention associated with mild creatine kinase-mb elevation. Circulation 2001;103:2780-2783	Individual cross sectional studies with consistently applied reference standard	Fourteen patients	Mild elevations in creatine kinase-MB (CK-MB) are common after successful percutaneous coronary interventions and are associated with future adverse cardiac events. The mechanism for CK-MB release remains unclear. A new contrast-enhanced MRI technique allows di-	Contrast-enhanced MRI demonstrated discrete regions of hyperenhancement within the target vessel perfusion territory in all 9 patients. Only one developed a new wall motion abnormality. The median estimated mass of myonecrosis was 2.0 g (range, 0.7 to 12.2 g), or 1.5% of left ventricular mass (range, 0.4% to 6.0%). Hyperenhancement persisted in 5 of the 6 who underwent a repeat MRI at 3 to 12 months. No control patient had hyperenhancement.	2

				rect visualization of myonecrosis.		
Q28	Eitel I, et al. Long-term prognostic value of myocardial salvage assessed by cardiovascular magnetic resonance in acute reperfused myocardial infarction. Heart 2011: 97:2038-2045	Follow-up study of non-randomized controlled cohort	208 consecutive patients with STEMI undergoing primary angioplasty <12 h after symptom onset	The aim of this study was to investigate whether the early prognostic significance of myocardial salvage assessed by CMR is sustained at long-term clinical follow-up in patients with ST-elevation myocardial infarction (STEMI) undergoing primary angioplasty.	The median MSI was 48 (IQR 27 to 73). Long term follow-up was available in 202 patients (97%) at a median of 18.5 months (IQR 13.8 to 20.8). Major adverse cardiovascular events occurred in 33 patients (16%), with a significantly lower event rate in the MSI≥ median group (7 vs 26 events, p<0.001). Mortality was significantly reduced in the MSI ≥ median group (2 vs 12 deaths, p¼0.001). MSI was a significant independent predictor for a favourable long-term survival on multivariable Cox regression analysis after adjustment for established prognostic markers.	3
Q29	Romero J, et al. CMR imaging assessing viability in patients with chronic ventricular dysfunction due to coronary artery disease: A meta-analysis of prospective trials. JACC. Cardiovascular imaging 2012;5:494-508	Meta-analysis	A total of 24 studies of CMR evaluating myocardial viability with 698 patients fulfilled the inclusion criteria.	The purpose of this study was to compare the diagnostic accuracy of cardiac magnetic resonance (CMR) assessing myocardial viability in patients with chronic left ventricular (LV) dysfunction due to coronary artery disease using 3 techniques: 1) end-diastolic wall thickness (EDWT); 2) low-dose dobutamine (LDD); and 3)	Eleven studies used DE, 9 studies used LDD, and 4 studies used EDWT. Our meta-analysis indicates that among CMR methods, DE CMR provides the highest sensitivity as well as the highest NPV (95% and 90%, respectively) for predicting improved segmental LV contractile function after revascularization, followed by EDWT CMR, whereas LDD CMR demonstrated the lowest sensitivity/NPV among all modalities. On the other hand, LDD CMR offered the highest specificity and PPV (91% and 93%, respectively), followed by DE CMR, whereas EDWT showed the lowest of these parameters.	1

				contrast delayed enhancement (DE).		
Q30	Roes SD, et al. Agreement and disagreement between contrast-enhanced magnetic resonance imaging and nuclear imaging for assessment of myocardial viability. European journal of nuclear medicine and molecular imaging 2009;36:594-601	Individual cross sectional studies with consistently applied reference standard	60 patients	The purpose of this study was to compare contrastenhanced MRI and nuclear imaging with 99mTc-tetrofosmin and 18F-fluorodeoxyglucose (18F-FDG) single photon emission computed tomography (SPECT) for assessment of myocardial viability.	Minimal scar tissue was observed on contrastenhanced MRI (scar score 0.4±0.8) in segments with normal perfusion/18F-FDG uptake, whereas extensive scar tissue (scar score 3.1±1.0) was noted in segments with severe perfusion/18F-FDG match ($p<0.001$). High agreement (91%) for viability assessment between contrastenhanced MRI and nuclear imaging was observed in segments without scar tissue on contrast-enhanced MRI as well as in segments with transmural scar tissue (83%). Of interest, disagreement was observed in segments with subendocardial scar tissue on contrast-enhanced MRI.	2
Q30	Crean A, et al. Assessment of myocardial scar; comparison between 18f-FDGpet, cmr and 99tc-sestamibi. Clinical Medicine: Cardiology 2009:69-76	Individual cross sectional studies with consistently applied reference standard	35 patients	Patients with heart failure and ischaemic heart disease may obtain benefit from revascularisation if viable dysfunctional myocardium is present. Such patients have an increased operative risk, so it is important to ensure that viability is correctly identified. In this study, we have compared the utility of 3	More segments were identified as nonviable scar using MIBI than with FDG or CMR. FDG identified the least number of scar segments per patient (7.4 +/- 4.8 with MIBI vs. 4.9 +/- 4.2 with FDG vs. 5.8 +/- 5.0 with CMR, $p = 0.0001$ by ANOVA). The strongest agreement between modalities was in the anterior wall with the weakest agreement in the inferior wall. Overall, the agreement between modalities was moderate to good.	2

				imaging modalities to detect myocardial scar.		
Q31-33	Klem I, Shah DJ, White RD, et al. Prognostic value of routine cardiac magnetic resonance assessment of left ventricular ejection fraction and myocardial damage: aninternational, multicenter study. Circ Cardiovasc Imaging 2011;4:610-619	Inception cohort	10 centers in 6 countries, consecutive patients, 1560 patients	To perform an international, multicenter study to assess the prognostic importance of routine CMR in patients with known or suspected heart disease.	The primary end point was all-cause mortality. A total of 1560 patients (age, 59±14 years; 70% men) were enrolled. Mean LVEF was 45±18%, and 1049 (67%) patients had hyperenhanced tissue (HE) on DE-CMR indicative of damage. During a median follow-up time of 2.4 years (interquartile range, 1.2, 2.9 years), 176 (11.3%) patients died. Patients who died were more likely to be older (P<0.0001), have coronary disease (P=0.004), have lower LVEF (P<0.0001), and have more segments with HE (P<0.0001). In multivariable analysis, age, LVEF, and number of segments with HE were independent predictors of mortality. Among patients with near-normal LVEF (≥50%), those with above-median HE (>4 segments) had reduced survival compared to patients with below- or at-median HE (P=0.02).	2
Q31-33	Jenkins C et al. Left ventricular volume measurement with echocardiography: A comparison of LV opacification, 3D-echocardiography, or both with magnetic resonance imaging. European heart journal 2009;30:98-106	Individual cross sectional studies with consistently applied reference standard	50 patients (46 men, age 63 ± 10 year) with past myocardial infarction	To examine the accuracy of non-contrast (NC) and CE-2DE and 3DE for calculation of LV volumes and ejection fraction (EF), relative to cardiac magnetic resonance imaging (MRI).	The mean LV end-diastolic volume (LVEDV) of the group by MRI was 207 ± 79 mL and was underestimated by 2DE (125 ± 54 mL, P = 0.005), and less by CE-2DE (172 ± 58 mL, P = 0.02) or 3DE (177 ± 64 mL, P = 0.08), but EDV was comparable by CE-3DE (196 ± 69 mL, P = 0.16). Limits of agreement with MRI were similar for NC-3DE and CE-2DE, with the best results for CE-3D. Results were similar for calculation of LVESV. Patients were categorized into groups of EF (≤35, 35–50, >50%) by MRI. NC-2DE	2

					demonstrated a 68% agreement (kappa 0.45, *P* = 0.001), CE-2DE a 62% agreement (kappa 0.20, *P* = 136), NC-3DE a 74% agreement (kappa 0.39, *P* = 0.005) and CE-3DE an 80% agreement (kappa 0.56, *P* < 0.001).	
Q31-33	Bellenger NG, Burgess MI, Ray SG, Lahiri A, Coats AJ, Cleland JG, et al. Comparison of left ventricular ejection fraction and volumes in heart failure by echocardiography, radionuclide ventriculography and cardiovascular magnetic resonance; are they interchangeable? European heart journal 2000;21:1387-1396	Individual cross sectional studies with consistently applied reference standard	Fifty two patients with chronic stable heart failure	To prospectively compare the agreement of left ventricular volumes and ejection fraction by M-mode echocardiography (echo), 2D echo, radionuclide ventriculography and cardiovascular magnetic resonance performed in patients with chronic stable heart failure.	The mean left ventricular ejection fraction by M-mode cube method was 39+/-16% and 29+/-15% by Teichholz M-mode method. The mean left ventricular ejection fraction by 2D echo Simpson's biplane was 31+/-10%, by radionuclude ventriculography was 24+/-9% and by cardiovascular magnetic resonance was 30+/-11. All the mean left ventricular ejection fractions by each technique were significantly different from all other techniques (P<0.001), except for cardiovascular magnetic resonance ejection fraction and 2D echo ejection fraction by Simpson's rule (P=0.23). The Bland-Altman limits of agreement encompassing four standard deviations was widest for both cardiovascular magnetic resonance vs cube M-mode echo and cardiovascular magnetic resonance vs Teichholz M-mode echo at 66% each, and was 58% for radionuclude ventriculography vs cube M-mode echo, 44% for cardiovascular magnetic resonance vs Simpson's 2D echo, 39% for radionuclide ventriculography vs Simpson's 2D echo, and smallest at 31% for cardiovascular magnetic resonance-radionuclide ventriculography. Similarly, the end-diastolic volume and end-systolic volume by 2D echo and cardiovascular magnetic resonance re-	2

					vealed wide limits of agreement (52 ml to 216 ml and 11 ml to 188 ml, respectively).	
Q31-33	Grothues F. et al. Comparison of interstudy reproducibility of cardiovascular magnetic resonance with two-dimensional echocardiography in normal subjects and in patients with heart failure or left ventricular hypertrophy. The American journal of cardiology 2002;90:29-34	Individual cross sectional studies with consistently applied reference standard	60 subjects(normal volunteers [n = 20], or patients with heart failure [n = 20] or LV hypertrophy [n = 20])	To compare the interstudy reproducibility of CMR with 2D echocardiography in normal subjects and in patients with heart failure or LV hypertrophy.	The interstudy reproducibility coefficient of variability was superior for CMR in all groups for all parameters. Statistical significance was reached for end-systolic volume (4.4% to 9.2% vs 13.7% to 20.3%, p <0.001), ejection fraction (2.4% to 7.3% vs 8.6% to 19.4%, p <0.001), and mass (2.8% to 4.8% vs 11.6% to 15.7% p <0.001), with a trend for end-diastolic volume (2.9% to 4.9% vs 5.5% to 10.5%, p = 0.17). The superior interstudy reproducibility resulted in considerably lower calculated sample sizes (reductions of 55% to 93%) required by CMR compared with echocardiography to show clinically relevant changes in LV dimensions and function.	2
Q34	Hamilton-Craig, C., et al. CT angiography with cardiac MRI: non-invasive functionaland anatomical assessment for the etiology in newly diagnosed heart failure. Int J Cardiovasc Imaging 2012;28(5):1111-1122	Individual cross sectional studies with consistently applied reference standard	28 prospectively enrolled patients	To demonstrate the hypothesis that a combined non-invasive strategy of CCTA with CMR accurately delineates the distribution and severity of coronary artery disease, as well as quantifying the degree of left ventricular dysfunction and viability, in patients with newly diagnosed HF.	The per-patient sensitivity and specificity of CCTA was 100% and 90%, respectively, negative predictive value (NPV) 100%, positive predictive value (PPV) 78%. Mean ejection fraction by CMR was 24%. Presence of ischemic-type LGE on CMR conferred a 67% sensitivity, 100% specificity, 90% NPV and 100% PPV. Combining CCTA with CMR conferred 100% specificity, 100% sensitivity, 100% PPV and 100% NPV for detection or exclusion of coronary disease.	2

Q34, 35	Valle-Munoz A et al. Late gadolinium enhancement–cardiovascular magnetic resonance identifies coronary artery disease as the aetiology of left ventricular dysfunction in acute new-onset congestive heart failure. Eur J Echocardiogr 2009;10(8):968-974	Individual cross sectional studies with consistently applied reference standard	100 consecutive patients	To evaluate the ability of late gadolinium enhancement (LGE) using cardiovascular magnetic resonance (CMR) to identify acute new-onset heart failure (HF) with left ventricular systolic dysfunction (LVSD), whether or not in relation to underlying coronary artery disease (CAD), in patients with no clinical evidence of associated ischaemic cardiomyopathy.	Hundred consecutive patients admitted with acute new-onset decompensated HF and EF<40%, with no clinical or electrocardiographic data suggestive of CAD. The patients were classified according to the presence or absence of significant CAD (stenosis ≥70% in at least one major vessel). Twenty-one patients (21%) had significant CAD. Seventy-nine (79%) had no lesions. Eighteen of the 21 patients (85%) with CAD had subendocardial/transmural LGE. In the diagnosis of CAD, LGE has a sensitivity of 85.7% (95% CI, 80–91) and specificity of 92.4% (95% CI, 87–96), respectively, with a negative predictive value of 96% (95% CI, 90–99). It has an area under the receiver operating characteristic curve of 0.906 (95% CI, 0.814–0.998).	2
Q36	Joshi SB, Connelly KA, Jimenez-Juan L, Hansen M, Kirpalani A, Dorian P, et al. Potential clinical impact of cardiovascular magnetic resonance assessment of ejection fraction on eligibility for cardioverter defibrillator implantation. Journal of cardiovascular magnetic res-	Individual cross sectional studies with consistently applied reference standard	Fifty-two patients	To investigate the potential impact of performing cardiovascular magnetic resonance (CMR) for EF on ICD eligibility.	Fifty-two patients (age 62±15 years, 81% male) had a mean EF of 38 ± 14% by echocardiography and 35 ± 14% by CMR. CMR had greater reproducibility than echocardiography for both intra-observer (ICC, 0.98 vs 0.94) and inter-observer comparisons (ICC 0.99 vs 0.93). The limits of agreement comparing CMR and echocardiographic EF were – 16 to +10 percentage points. CMR resulted in 11 of 52 (21%) and 5 of 52 (10%) of patients being reclassified regarding ICD eligibility at the EF thresholds of 35 and 30% respectively. Among patients with an echocardiographic EF of between 25 and 40%, 9	2

	onance : official journal of the Society for Cardiovascular Magnetic Resonance 2012;14:69				of 22 (41%) were reclassified by CMR at either the 35 or 30% threshold. Echocardiography identified only 1 of the 6 patients with left ventricular thrombus noted incidentally on CMR.	
Q36	Gao P, Yee R, Gula L, Krahn AD, Skanes A, Leong-Sit P, et al. Prediction of arrhythmic events in ischemic and dilated cardiomyopathy patients referred for implantable cardiac defibrillator: Evaluation of multiple scar quantification measures for late gadolinium enhancement magnetic resonance imaging. Circulation. Cardiovascular imaging 2012;5:448-456	Inception cohort	One hundred twenty-four consecutive patients	To evaluate the predictive use of multiple scar quantification measures in ICM and DCM patients being referred for ICD.	Patients were followed prospectively for the primary combined outcome of appropriate ICD therapy, survived cardiac arrest, or sudden cardiac death. At a mean follow-up of 632 ± 262 days, 18 patients (15%) had suffered the primary outcome. Total scar was significantly higher among those suffering a primary outcome, a relationship maintained within each cardiomyopathy cohort ($P<0.01$ for all comparisons). Total scar was the strongest independent predictor of the primary outcome and demonstrated a negative predictive value of 86%. In the ICM subcohort, peri-infarct signal showed only a nonsignificant trend toward elevation among those having a primary end point.	2
Q36	Klem I, Weinsaft JW, Bahnson TD, Hegland D, Kim HW, Hayes B, et al. Assessment of myocardial scarring improves risk stratification in patients evaluated for cardiac de-	Inception cohort	One hundred thirty-seven patients	To test whether an assessment of myocardial scarring by cardiac magnetic resonance imaging (MRI) would improve risk stratification in patients evaluated for implantable	During a median follow-up of 24 months the primary endpoint occurred in 39 patients.Whereas the rate of adverse events steadily increased with decreasing LVEF, a sharp step-up was observed for scar size >5% of LV mass (HR=5.2 [95% CI, 2.0-13.3]). On multivariable Cox proportional hazards analysis, including LVEF and electrophysiological-study results, scar size (as a continuous	2

	fibrillator implantation. Journal of the American College of Cardiology 2012;60:408-420			cardioverter-defibrillator (ICD) implantation.	variable or dichotomized at 5%) was an independent predictor of adverse outcome. Among patients with LVEF >30%, those with significant scarring (>5%) had higher risk than those with minimal-or-no (≤5%) scarring (HR=6.3 [1.4-28.0]). Those with LVEF >30% and significant scarring had similar risk to patients with LVEF ≤30% (p=0.56). Among patients with LVEF ≤30%, those with significant scarring again had higher risk than those with minimal-or-no scarring (HR=3.9 [1.2-13.1]). Those with LVEF ≤30% and minimal scarring had similar risk to patients with LVEF >30% (p=0.71).	
Q37	Leyva F, Foley PW, Chalil S, Ratib K, Smith RE, Prinzen F, et al. Cardiac resynchronization therapy guided by late gadolinium-enhancement cardiovascular magnetic resonance. Journal of cardiovascular magnetic resonance : official journal of the Society for Cardiovascular Magnetic Resonance 2011;13:29	Inception cohort	559 patients	To determine whether the use of late gadolinium cardiovascular magnetic resonance (LGE-CMR) to guide left ventricular (LV) lead deployment influences the long-term outcome of cardiac resynchronization therapy (CRT).	Over a maximum follow-up of 9.1 yrs, +CMR+S had the highest risk of cardiovascular death (HR: 6.34), cardiovascular death or hospitalizations for heart failure (HR: 5.57) and death from any cause or hospitalizations for major adverse cardiovascular events (HR: 4.74) (all P < 0.0001), compared with +CMR-S. An intermediate risk of meeting these endpoints was observed for -CMR, with HRs of 1.51 (P = 0.0726), 1.61 (P = 0.0169) and 1.87 (p = 0.0005), respectively. The +CMR+S group had the highest risk of death from pump failure (HR: 5.40, p < 0.0001) and sudden cardiac death (HR: 4.40, p = 0.0218), in relation to the +CMR-S group.	2
Q37	Delgado V, van Bommel RJ, Bertini M, Borleffs CJ,	Inception cohort	397 patients	To evaluate whether the relative merits of left ven-	Mean baseline LV radial dyssynchrony was 133_98 milliseconds. In 271 patients (68%), the LV lead was placed at	2

	Marsan NA, Arnold CT, et al. Relative merits of left ventricular dyssynchrony, left ventricular lead position, and myocardial scar to predict long-term survival of ischemic heart failure patients undergoing cardiac resynchronization therapy. Circulation 2011;123:70-78			tricular (LV) dyssynchrony, LV lead position, and myocardial scar can predict long-term outcome after cardiac resynchronization therapy.	the latest activated segment (concordant LV lead position), and the mean value of peak radial strain at the targeted segment was 18.9±12.6%. Larger LV radial dyssynchrony at baseline was an independent predictor of superior long-term survival (hazard ratio, 0.995; *P*=0.001), whereas a discordant LV lead position (hazard ratio, 2.086; *P*=0.001) and myocardial scar in the segment targeted by the LV lead (hazard ratio, 2.913; *P*< 0.001) were independent predictors of worse outcome. Addition of these 3 parameters yielded incremental prognostic value over the combination of clinical parameters.	
Q38	Dickfeld T, Tian J, Ahmad G, Jimenez A, Turgeman A, Kuk R, et al. Mri-guided ventricular tachycardia ablation: Integration of late gadolinium-enhanced 3d scar in patients with implantable cardioverter-defibrillators. Circulation. Arrhythmia and electrophysiology 2011;4:172-184	Case series	22 patients	To demonstrate that an integrated 3D scar reconstruction from late gadolinium enhancement (LGE) MRI could facilitate VT ablations.	ICD imaging artifacts were most prominent in the anterior wall and allowed full and partial assessment of LGE in 9±4 and 12±3 of 17 segments, respectively. In 14 patients with LGE, a 3D scar model was reconstructed and successfully registered with the clinical mapping system (accuracy, 3.9±1.8 mm). Using receiver operating characteristic curves, bipolar and unipolar voltages of 1.49 and 4.46 mV correlated best with endocardial MRI scar. Scar visualization allowed the elimination of falsely low voltage recordings (suboptimal catheter contact) in 4.1±1.9% of <1.5-mV mapping points. Display of scar border zone allowed identification of excellent pace mapping sites, with only limited voltage mapping in 64% of patients. Viable endocardium of >2 mm resulted in >1.5-mV voltage recordings despite up to 63% transmural midmyo-	4

					cardial scar successfully ablated with MRI guidance. All successful ablation sites demonstrated LGE (transmurality, 68±26%) and were located within 10 mm of transition zones to 0% to 25% scar in 71%.	
Q38	Junttila MJ, Fishman JE, Lopera GA, Pattany PM, Velazquez DL, Williams AR, et al. Safety of serial MRI in patients with implantable cardioverter defibrillators. Heart 2011;97:1852-1856	Case series	10patients	To evaluated the safety of serial cardiac MR scans in patients with implantable cardioverter defibrillators (ICDs).	In all patients MR scanning occurred without complications. There were no differences between pre and post-MR pacing capture threshold, pacing lead or high voltage lead impedance, or battery voltage values. During follow-up there were no occurrences of ICD dysfunction. Although most patients had image artifacts, the studies were generally diagnostic regarding left ventricular function and wall motion. Delayed enhancement imaging was of good quality for inferior wall and inferolateral infarcts, but ICD artifacts often affected the imaging of anterior wall infarcts.	4
Q39	Beerbaum P, Korperich H, Gieseke J, Barth P, Peuster M, Meyer H. Rapid left-to-right shunt quantification in children by phase-contrast magnetic resonance imaging combined with sensitivity encoding (sense). Circulation 2003;108:1355-1361	Studies without consistently applied reference standards	22	Parallel imaging by sensitivity encoding (SENSE) may considerably reduce scan time in MRI. For rapid flow quantification in children with congenital heart disease, we evaluated phase-contrast MRI (PC-MRI) techniques combined with SENSE.	In 22 pediatric patients (mean age, 7.2+/-6.2 years) with cardiac left-to-right shunt, blood flow rate in the pulmonary artery (Qp) and ascending aorta (Qs) and flow ratio Qp/Qs were determined by PC-MRI with SENSE reduction-factor 2 and 3 (SF-2 and SF-3). Additionally, we used PC-MRI with higher spatial in-plane resolution (1.6x2.1 versus 2.3x3.1 mm) with and without SF-3. Results were compared with a recently validated standard PC-MRI protocol and tested in vitro using a pulsatile flow phantom. Reduction of signal averages from 2 to 1 and application of SENSE accelerated flow measurements by a	3

					factor of 3.5 (5.2) using PC-MRI with SF-2 (SF-3) compared with standard PC-MRI. For blood flow rate through the pulmonary artery and aorta, as well as for the Qp/Qs ratio we found negligible differences of +/-3%, lower limits of agreement (mean+/-2 SD) of -7% to -18%, and upper limits of agreement (mean+/-2 SD) of +3 to +24%, demonstrating good agreement with standard PC-MRI. Mean Qp/Qs ratio by standard PC-MRI was 1.69+/-0.45 (range, 1.27 to 2.79). Interobserver variability was low, and high accuracy was confirmed in vitro for all protocols.	
Q39	Korperich H, Gieseke J, Barth P, Hoogeveen R, Esdorn H, Peterschroder A, et al. Flow volume and shunt quantification in pediatric congenital heart disease by real-time magnetic resonance velocity mapping: A validation study. Circulation 2004;109:1987-1993	Studies without consistently applied reference standards	14 pediatric patients	Flow quantification in real time by phase-contrast MRI (PC-MRI) may provide unique hemodynamic information in congenital heart disease, but available techniques have important limitations. We sought to validate a novel real-time magnetic resonance flow sequence in children.	In 14 pediatric patients (mean age 5.2+/-2.0 years) with cardiac left-to-right shunt, pulmonary (Q(p)) and aortic (Q(s)) flow rates were determined by nontriggered free-breathing real-time PC-MRI with single-shot echo-planar imaging combined with sensitivity encoding, which yielded 25 phase images per second at 2.7x2.7-mm in-plane resolution (field of view 30x34 cm2). Over a 9.5-second period that included 2 to 5 respiratory cycles, 16.6+/-2.6 subsequent stroke volumes (range 13 to 22) were acquired in each vessel. Results were compared with conventional retrospectively ECG-gated PC-MRI. Mean Q(p)/Q(s) by conventional PC-MRI was 1.91+/-0.64, and it was 1.94+/-0.68 (mean+/-SD) by real-time PC-MRI. For blood flow rate through pulmonary artery and aorta, we found differences of 2% to 3% (Bland-Altman analysis),	3

					with lower limits of agreement of -11% to -13% (mean-2 SD) and upper limits of 18% to 19% (mean+2 SD), which demonstrated good agreement between both methods. Mean difference for Q(p)/Q(s) was 1%, with limits of agreement ranging between -18% and 22% (mean+/-2 SD). High repeatability but some flow overestimation was observed in vitro (pulsatile flow phantom) with real-time PC-MRI, whereas conventional PC-MRI was accurate. Beat-to-beat stroke-volume variation was 6.1+/-2.3% in vivo and 3.7+/-0.3% in vitro.	
Q39	Prasad SK, Soukias N, Hornung T, Khan M, Pennell DJ, Gatzoulis MA, et al. Role of magnetic resonance angiography in the diagnosis of major aortopulmonary collateral arteries and partial anomalous pulmonary venous drainage. Circulation 2004;109:207-214	Studies without consistently applied reference standards	29 consecutive adult patients	Accurate diagnosis of major aortopulmonary collaterals (MAPCAs) and partial anomalous pulmonary venous drainage (PAPVD) in adult patients with congenital heart disease is important but problematic. Three-dimensional contrast-enhanced magnetic resonance angiography (MRA) provides a minimally invasive technique to allow detailed studies in a single breath-hold.	We assessed the role of contrast-enhanced 3D MRA in 29 consecutive adult patients with a diagnosis of MAPCAs (n=16) or PAPVD (n=13) made by echocardiogram, cardiac catheterization, or surgical inspection. MRA was performed with a 3D spoiled gradient-echo technique with intravenous gadolinium-DTPA (0.2 mmol/kg). In both types of pathology, there was excellent correlation between MRA and the cardiac catheterization, echocardiogram, or surgical inspection. Additional information was gained for patients with MAPCAs on confluence and size of pulmonary arteries (n=13 had central arteries), pulmonary artery stenosis (n=3), aneurysmal dilatation of pulmonary artery (n=1), and additional anomalous vascular abnormality (n=3). Shunt assessment, where present (9 of 16), showed patency in all cases (100%). For adults with PAPVD, further information was obtained on drain-	3

					age origin (n=11). There were no complications.	
Q39	Taylor AM, Thorne SA, Rubens MB, Jhooti P, Keegan J, Gatehouse PD, et al. Coronary artery imaging in grown up congenital heart disease: Complementary role of magnetic resonance and x-ray coronary angiography. Circulation 2000;101:1670-1678	Individual cross sectional studies with consistently applied reference standard	Twenty-five adults with various congenital heart abnormalities	To compare the use of x-ray angiography and MRCA for identification of the coronary artery origin and proximal course in adults with a variety of congenital heart abnormalities.	Twenty-five adults with various congenital heart abnormalities were studied. X-ray coronary angiography and respiratory-gated MRCA were performed in all subjects. Coronary artery origin and proximal course were assessed for each imaging modality by separate, blinded investigators. Images were then compared, and a consensus diagnosis was reached. With the consensus readings for both magnetic resonance and x-ray coronary angiography, it was possible to identify the origin and course of the proximal coronary arteries in all 25 subjects: 16 with coronary anomalies and 9 with normal coronary arteries. Respiratory-gated MRCA had an accuracy of 92%, a sensitivity of 88%, and a specificity of 100% for the detection of abnormal coronary arteries. The MRCA results were more likely to agree with the consensus for definition of the proximal course of the coronary arteries ($P<0.02$).	2
Q40	Lemmer, J. et al. Right ventricular function in grown-up patients after correction of congenital right heart disease. Clin Res Cardiol 2011;100(4): 289-296	Individual cross sectional studies with consistently applied reference standard	104 GUCH patients, multicenter, prospective	We investigated whether a correlation exists between biomarkers of the neurohumoral system and clinical markers in grown-up patients with congenital heart disease (GUCH) and right ventricular function.	Prospective, cross-sectional, multicenter study of 104 GUCH patients (median) 16 years (range 6-43 years) after corrective surgery with RV pressure and/or volume overload and 54 healthy controls. Clinical, functional, and laboratory parameters were assessed. Natriuretic peptide levels were significantly increased in GUCH patients (NTproBNP 101 vs. 25 pg/ml, $p < 0.001$), but we observed no differences in norepinephrine, aldosterone,	2

					angiotensin II and Endothelin-1 levels. NTproBNP correlated significantly with clinical markers such as NYHA classification, prolonged QRS duration and reduced exercise capacity (VO(2) peak) (all p < 0.001), as well as self-reported quality of life (p < 0.001). MRI and echocardiography derived RV volumes were elevated and ejection fraction reduced in the patients (both p < 0.001). Tissue Doppler parameter showed significantly restricted ventricular longitudinal systolic function (longitudinal tricuspid valve movement, 1.7 vs. 2.3 cm, p < 0.001), suggesting stiffness and reduced RV compliance.	
Q40	Oosterhof T, Mulder BJ, Vliegen HW, de Roos A. Corrected tetralogy of fallot: Delayed enhancement in right ventricular outflow tract. Radiology 2005;237:868-871	Studies without consistently applied reference standards	24 consecutive patients	To evaluate retrospectively the presence of fibrosis and largest diameter of the right ventricular outflow tract (RVOT) by using delayed enhancement magnetic resonance (MR) imaging in patients who had undergone initial correction for tetralogy of Fallot.	Delayed enhancement was seen in 17 patients in the RVOT. During initial surgery, transannular patching was performed in 13 (76%) of 17 patients, RVOT patching in one (6%) of 17 patients, and the Brock procedure in two (12%) of 17 patients. In one patient, the type of initial RVOT repair was unknown. Patients with delayed enhancement in the RVOT, as compared with those without delayed enhancement in the RVOT, had increased RVOT diameter (32 mm +/- 7 [standard deviation] vs 22 mm +/- 3, P < .01), decreased right ventricular ejection fraction (43% +/- 6.3 vs 54% +/- 10, P < .001), and increased end-diastolic volume (175 mL/m2 +/- 42 vs 118 mL/m2 +/- 34, P < .01). The diameter of the RVOT correlated with increased right ventricular end-systolic volume (R = 0.86) and was inversely related to ejection fraction	3

					(R = -0.65).	
Q40	Davlouros PA et al. Right ventricular function in adults with repaired tetralogy of fallot assessed with cardiovascular magnetic resonance imaging: Detrimental role of right ventricular outflow aneurysms or akinesia and adverse right-to-left ventricular interaction. Journal of the American College of Cardiology 2002;40:2044-2052	Case-control studies	85 consecutive adults with rTOF and 26 matched healthy controls	We examined the relationship among biventricular hemodynamics, pulmonary regurgitant fraction (PRF), right ventricular outflow tract (RVOT) aneurysm or akinesia, and baseline and surgical characteristics in adults with repaired tetralogy of Fallot (rTOF).	Patients had higher right ventricular end-diastolic volume index (RVEDVi) ($p < 0.001$), right ventricular end-systolic volume index (RVESVi) ($p < 0.001$), right ventricular mass index (RVMi) ($p < 0.001$), and lower right ventricular ejection fraction (RVEF) ($p < 0.001$) and left ventricular ejection fraction (LVEF) ($p = 0.002$) compared to controls. The PRF (range 0% to 55%) independently predicted RVEDVi ($p < 0.01$) and the latter predicted RVESVi ($p < 0.01$) and RVMi ($p < 0.01$). The RVOT aneurysm/akinesia was present in 48/85 (56.9%) of patients and predicted RV volumes (RVEDVi, $p = 0.01$, and RVESVi, $p = 0.03$). There was a negative effect of RVOT aneurysm/akinesia and RVMi on RVEF ($p < 0.01$ and $p = 0.02$, respectively). There was only a tendency among patients with transannular or RVOT patching toward RVOT aneurysm/akinesia ($p = 0.09$). The LVEF correlated with RVEF ($r = 0.67$, $p < 0.001$).	4
Q41	Caruthers SD, Lin SJ, Brown P, Watkins MP, Williams TA, Lehr KA, et al. Practical value of cardiac magnetic resonance imaging for clinical quantification of aortic valve stenosis: Comparison with	Individual cross sectional studies with consistently applied reference standard	24	To define the reliability of velocity-encoded CMR as a routine method for quantifying stenotic aortic valve area, to compare this method with the accepted standard, and to evaluate its reproducibility.	Patients (n=24) with aortic stenosis (ranging from 0.5 to 1.8 cm2) were imaged with CMR and echocardiography. Velocity-encoded CMR was used to obtain velocity information in the aorta and left ventricular outflow tract. From this flow data, pressure gradients were estimated by means of the modified Bernoulli equation, and VTIs were calculated to estimate aortic valve orifice dimensions by means of the continuity equation. The correla-	2

	echocardiography. Circulation 2003;108:2236-2243				tion coefficients between modalities for pressure gradients were r=0.83 for peak and r=0.87 for mean. The measurements of VTI correlated well, leading to an overall strong correlation between modalities for the estimation of valve dimension (r=0.83, by means of the identified best approach). For 5 patients, the CMR examination was repeated using the best approach. The repeat calculations of valve size correlated well (r=0.94).	
Q41	Botnar, R., et al. Assessment of prosthetic aortic valve performance by magnetic resonance velocity imaging. MAGMA 2000;10(1):18-26	Individual cross sectional studies with consistently applied reference standard	13 patients	Magnetic resonance (MRI) velocity mapping was used to evaluate noninvasively the flow profiles of the ascending aorta in normal volunteers and in patients with an aortic (mechanical) valve prosthesis.	Peak flow velocity during mid-systole was significantly higher in patients with valvular prosthesis than in normals (mean + SD, 1.9 +/- 0.4 m/s vs. 1.2 +/- 0.03 m/s, P < 0.001) with a double peak and a zone of reversed flow close to the inner (left lateral) wall of the ascending aorta of the patients. Closing volume was significantly larger in patients than in controls (-3.3 +/- 1.2 ml/beat vs. -0.9 +/- 0.5 ml/beat; P < 0.001). There was reverse flow during systole in valvular patients amounting to 15.7 +/- 6.7% of total cardiac output compared to 2.3 +/- 1.2% in controls (P < 0.001). Diastolic mean flow was negative in patients after valve replacement but not in controls (-11.0 +/- 15.2 ml/beat vs. 6.8 +/- 3.2 ml/beat; P < 0.01).	2
Q41	von Knobelsdorff-Brenkenhoff F, Rudolph A, Wassmuth R, et al: Feasibility of cardiovascular magnetic resonance to	Individual cross sectional studies with consistently applied	65 patients	To investigate the feasibility of cardiovascular magnetic resonance (CMR) to assess the orifice areas of aortic bioprostheses.	CMR planimetry was readily feasible in 80.0%; feasible with limitation in 15.4% because of stent, flow, and sternal wire artifacts; and impossible in 4.6% because of flow artifacts. Correlations of the orifice areas by CMR with TTE (r=0.82) and CMR with TEE (r=0.92) were significant.	2

	assess the orifice area of aortic bioprostheses. Circ Cardiovasc Imaging 2009;2:397-404	reference standard			The average difference between the methods was -0.02+/-0.24 cm(2) (TTE) and 0.05+/-0.15 cm(2) (TEE). Agreement was present for stented and stentless devices and independent of orifice size. Intraobserver and interobserver variabilities of CMR planimetry were 6.7+/-5.4% and 11.5+/-7.8%.	
Q42	Keller, D. I., et al. Arrhythmogenic right ventricular cardiomyopathy: Diagnostic and prognostic value of the cardiac mri in relation to arrhythmia-free survival 2003:19(6):537-543	Individual cross sectional studies with consistently applied reference standard	Thirty-six patients with suspected ARVC	The aim of this study was to evaluate the diagnostic and prognostic value of CMR in patients with suspected ARVC and to assess the long-term outcome of patients with CMR-diagnosed ARVC.	Thirty-six patients with suspected ARVC (26 male, 10 female, median age 41 years) underwent non-invasive and invasive clinical tests as gold standard for ARVC diagnosis. ARVC was clinically diagnosed in 19 patients and excluded in 17 patients. Both groups underwent CMR, and diagnosis was confirmed by CMR in 16/18 patients with clinically diagnosed ARVC (sensitivity 89%), and correctly excluded in 14/17 of patients with clinically excluded ARVC (specificity 82%). This result indicates a positive predictive value of the CMR of 84%, and a negative predictive value of 88%, respectively ($p < 0.0001$). Using a scoring system, multiple CMR parameters were compared in the two groups in regard of the clinical diagnosis. By univariate analysis, right ventricular fatty tissue infiltration ($p = 0.0003$) was predictive for diagnosis. Compared by outcome, 37% of patients with clinically and by CMR-diagnosed ARVC had an arrhythmic event during a mean follow-up of 16 +/- 11 months.	2
Q42	Tandri H, Saranathan M, Rodriguez ER, et al. Non-	Individual cross sec-	30 patients	We evaluated the role of myocardial delayed-	Twelve (40%) of 30 patients met the Task Force criteria for ARVD/C. Eight (67%) of the 12 ARVD/C patients	2

	invasive detection of myocardial fibrosis in-arrhythmogenic right ventricular cardiomyopathy using delayed-enhancement magnetic resonance imaging. J Am Coll Cardiol 2005;45:98-103	tional studies with consistently applied reference standard		enhancement (MDE) magnetic resonance imaging (MRI) for noninvasive detection of fibrosis in Arrhythmogenic right ventricular dysplasia/cardiomyopathy (ARVD/C).	demonstrated increased signal on MDE-MRI in the RV compared with none (0%) of the 18 patients without ARVD/C (p <0.001). Endomyocardial biopsy was performed in 9 of the 12 ARVD/C patients. Of the nine patients, four had fibro-fatty changes consistent with the diagnosis of ARVD/C. Each of these patients had increased RV signal on MDE-MRI. None of the patients without ARVD/C had any abnormalities either on histopathology or on MDE-MRI. Electrophysiologic testing revealed inducible sustained ventricular tachycardia (VT) in six of the eight ARVD/C patients with delayed enhancement, compared with none of the ARVD/C patients without delayed enhancement (p=0.01).	
Q42	Sen-Chowdhry S, Prasad SK, Syrris P, et al. Cardiovascular magnetic resonance in arrhythmogenic right ventricular cardiomyopathy revisited: comparison with task force criteria and genotype. J Am Coll Cardiol 2006;48:2132-2140	Individual cross sectional studies with consistently applied reference standard	232 patients	We sought to assess the utility of cardiovascular magnetic resonance (CMR) in the evaluation of arrhythmogenic right ventricular cardiomyopathy (ARVC) in relation to diagnostic criteria and genotype.	CMR studies were positive in all 64 patients who prospectively fulfilled Task Force criteria, resulting in 100% sensitivity. Specificity in relation to Task Force criteria was low (29%). Of the 119 apparent false positives detected by CMR, however, 63 fulfilled modified diagnostic criteria for familial ARVC and 7 were obligate gene carriers, suggesting that CMR frequently identifies individuals with early disease, in whom Task Force criteria are relatively insensitive. This was borne out by evaluation of genotyped individuals (26 gene-positive and 9 gene-negative), in whom CMR had a sensitivity of 96% and a specificity of 78%.	2
Q43	Monney, P. A.et al.	Case series	79 patients	To analyse cardiac mag-	79 patients referred for CMR following an admission with	4

	Acute myocarditis presenting as acute coronary syndrome: role of early cardiac magnetic resonance in its diagnosis. Heart 2011;97(16):1312-1318			netic resonance (CMR) findings in patients with a provisional diagnosis of acute coronary syndrome (ACS) in whom acute myocarditis was subsequently considered more likely.	presumed ACS and raised serum troponin in whom no culprit lesion was detected were studied. 13% had unrecognised myocardial infarction and 6% takotsubo cardiomyopathy. The remainder (81%) were diagnosed with myocarditis. Mean age was 45+/-15 years and 70% were male. Left ventricular ejection fraction (EF) was 58+/-10%; myocardial oedema was detected in 58%. A myocarditic pattern of late gadolinium enhancement (LGE) was detected in 92%. Abnormalities were detected more frequently in scans performed within 2 weeks of symptom onset: oedema in 81% vs 11% (p<0.0005), and LGE in 100% vs 76% (p<0.005). In 20 patients with both an acute (<2 weeks) and convalescent scan (>3 weeks), oedema decreased from 84% to 39% (p<0.01) and LGE from 5.6 to 3.0 segments (p=0.005). Three patients presented with sustained ventricular tachycardia, another died suddenly 4 days after admission and one resuscitated 7 weeks following presentation. All 5 patients had preserved EF.	
Q43	Mahrholdt H, Goedecke C, Wagner A, *et al.*: Cardiovascular magnetic resonance assessment of human myocarditis: a comparison to histology and molecular pathology. Cir-	Individual cross sectional studies with consistently applied reference standard	58 consecutive patients	To determine whether contrast CMR using new IR-GRE techniques visualizes areas of active myocarditis compared with the "gold standard," histopathology.	Contrast enhancement was present in 28 patients (88%) and was usually seen with one or several foci in the myocardium. Foci were most frequently located in the lateral free wall. In the 21 patients in whom biopsy was obtained from the region of contrast enhancement, histopathologic analysis revealed active myocarditis in 19 patients (parvovirus B19, n=12; human herpes virus type	2

	culation 2004;109:1250-1258				6 [HHV 6], n=5). Conversely, in the remaining 11 patients, in whom biopsy could not be taken from the region of contrast enhancement, active myocarditis was found in one case only (HHV6). At follow-up, the area of contrast enhancement decreased from 9+/-11% to 3+/-4% of left ventricular mass as the left ventricular ejection fraction improved from 47+/-19% to 60+/-10%.	
Q43	Jeserich. M. et al. Diagnosis of viral myocarditis by cardiac magnetic resonance and viral genome detection in peripheral blood. Int J Cardiovasc Imaging 2013;29(1):121-129	Individual cross sectional studies with consistently applied reference standard	55 consecutive patients	We assessed the association of viral genome presence in peripheral blood samples with myocardial edema and irreversible injury.	The specificity of viral amplification products was confirmed by automatic DNA sequencing. Of a total of 55 patients (53.5 +/- 15.6 years), 21 were positive for viral genome in peripheral leukocytes. Interestingly, 18 (86%) of these patients also showed global myocardial edema, as compared to only 7/34 (21%) without PCR evidence for viral genome. The overall agreement between CMR criteria for edema and viral PCR was 84%. In contrast, there was no significant relationship of viral genome presence with myocardial necrosis or scars. In patients with clinically suspected myocarditis, myocardial edema but not irreversible myocardial injury is associated with the presence of viral genome in peripheral blood.	2
Q44	Hosch, W., et al. Late enhancement in cardiac amyloidosis: correlation of MRI enhancement pattern with histopathological findings. Amyloid 2008;	Individual cross sectional studies with consistently applied reference	5 patients	To correlate LE and histomorphological findings in five patients with advanced CA	Histological amyloid and collagenous fiber deposition was correlated with LE in corresponding MRI slides. LE was visualized in 103/180 (57.2%) predominantly subendocardial segments. Histological analysis of amyloid deposition was (peri-)vascular (n=5), diffuse interstitial (n=3) and/or nodular (n=4). Extent of fibrosis was mod-	2

	15(3):196-204	standard			erate to severe. Cytoplasmatic vacuolization and decline of myofibrils was seen in all patients. Fibrosis was significantly associated with LE in subendocardial and midmural localizations ($p<0.05$), whereas the extent of amyloid deposition was not associated with LE findings in any region. LE seems to be associated with fibrosis due to ischemia of cardiomyocytes by small vessel amyloid deposition rather than with amyloid deposition in CA, suggesting that amyloid deposition might be present prior to LE detection.	
Q44	Smedema, J. P., et al. Evaluation of the Accuracy of Gadolinium-Enhanced Cardiovascular Magnetic Resonance in the Diagnosis of Cardiac Sarcoidosis. J Am Coll Cardiol 2005;45(10):1683-1690	Individual cross sectional studies with consistently applied reference standard	58 patients	To analyze the accuracy of gadolinium-enhanced cardiovascular magnetic resonance (CMR) for the diagnosis of cardiac sarcoidosis (CS).	The diagnosis of CS was made in 12 of 58 patients (21%); CMR revealed late gadolinium enhancement (LGE), mostly involving basal and lateral segments (73%), in 19 patients. In 8 of the 19 patients, scintigraphy was normal, while patchy LGE was present. The sensitivity and specificity of CMR were 100% (95% confidence interval, 78% to 100%) and 78% (95% confidence interval, 64% to 89%), and the positive and negative predictive values were 55% and 100%, respectively, with an overall accuracy of 83%.	2
Q45, 46	Moon JC, Fisher NG, McKenna WJ, *et al.*: Detection of apical hypertrophic cardiomyopathy by cardiovascular magnetic resonance in patients	Individual cross sectional studies with consistently applied reference		To investigate the role of cardiovascular magnetic resonance (CMR) in a series of patients with ECG repolarisation changes and normal echocardiog-	Apical HCM detected by CMR could be morphologically severe with wall thickness up to 28 mm, or mild. The extent of repolarisation abnormalities did not correlate to the morphological severity.	2

	with non-diagnostic echocardiography. Heart 2004;90:645-649	standard		raphy.		
Q45, 46	Maron, M. S., et al. Hypertrophic cardiomyopathy phenotype revisited after 50 years with cardiovascular magnetic resonance. J Am Coll Cardiol 2009;54(3):220-228	Case-series	333 consecutive HCM patients	To characterize the pattern and distribution of left ventricular (LV) hypertrophy by cardiovascular magnetic resonance (CMR) to more precisely define phenotypic expression and its clinical implications in hypertrophic cardiomyopathy (HCM).	Basal anterior LV free wall and the contiguous anterior ventricular septum were the most commonly hypertrophied segments (n = 256; 77%). LV hypertrophy was focal (involving < or = 2 segments [< or = 12% of LV]) in 41 patients (12%), intermediate (3 to 7 segments [13% to 49% of LV]) in 112 patients (34%), and diffuse (> or = 8 segments [> or = 50% of LV]) in 180 patients (54%); 42 patients (13%) showed hypertrophied segments separated by regions of normal thickness. The number of hypertrophied segments was greater in patients with LV outflow tract obstruction (> or = 30 mm Hg) than without (10 +/- 4 vs. 8 +/- 4 per patient; p = 0.0001) and was associated with an advanced New York Heart Association functional class (p = 0.007). LV wall thickness was greater in segments with late gadolinium enhancement than without (20 +/- 6 mm vs. 16 +/- 6 mm; p < 0.001). We also identified 40 (12%) of HCM patients with segmental LV hypertrophy largely confined to the anterolateral free wall, posterior septum, or apex, which was underestimated or undetected by echocardiography.	4
Q45, 46	Rickers, C., et al. Utility of cardiac magnetic resonance imaging in the di-	Individual cross sectional studies	48 patients	To determine whether cardiac MRI (CMR) affords greater accuracy than	Forty-eight patients (age 34+/-16 years) suspected of having HCM (or with a confirmed diagnosis) were imaged by both echocardiography and CMR to assess LV	2

	agnosis of hypertrophic cardiomyopathy. Circulation 2005;112(6):855-861	with consistently applied reference standard		echocardiography in establishing the diagnosis and assessing the magnitude of left ventricular (LV) hypertrophy in HCM.	wall thickness in 8 anatomic segments (total n=384 segments) and compared in a blinded fashion. Maximum LV thickness was similar by echocardiography (21.7+/-9.1 mm) and CMR (22.5+/-9.6 mm; P=0.21). However, in 3 (6%) of the 48 patients, echocardiography did not demonstrate LV hypertrophy, and CMR identified otherwise undetected areas of wall thickening in the anterolateral LV free wall (17 to 20 mm), which resulted in a new diagnosis of HCM. In the overall study group, compared with CMR, echocardiography also underestimated the magnitude of hypertrophy in the basal anterolateral free wall (by 20+/-6%; P=0.001), as well as the presence of extreme LV wall thickness (> or =30 mm) in 10% of patients (P<0.05).	
Q47	Green, J. J., et al. Prognostic value of late gadolinium enhancement in clinical outcomes for hypertrophic cardiomyopathy. JACC Cardiovasc Imaging 2012;5(4):370-377	Systematic review	Four studies, 1,063 patients	The objective of this study was to perform a systematic review and meta-analysis of the predictive value of late gadolinium enhancement (LGE) cardiac magnetic resonance (CMR) for future cardiovascular events and death in hypertrophic cardiomyopathy (HCM).	Four studies evaluated 1,063 patients over an average follow-up of 3.1 years. The pooled prevalence of LGE was 60%. The pooled odds ratios (OR) demonstrate that LGE by CMR correlated with cardiac death (pooled OR: 2.92, 95% confidence interval [CI]: 1.01 to 8.42; p = 0.047), heart failure death (pooled OR: 5.68, 95% CI: 1.04 to 31.07; p = 0.045), and all-cause mortality (pooled OR: 4.46, 95% CI: 1.53 to 13.01; p = 0.006), and showed a trend toward significance for predicting sudden death/aborted sudden death (pooled OR: 2.39, 95% CI: 0.87 to 6.58; p = 0.091).	1

Q48	Beroukhim RS, et al. Characterization of cardiac tumors in children by cardiovascular magnetic resonance imaging: A multicenter experience. Journal of the American College of Cardiology 2011; 58:1044-1054	Individual cross sectional studies with consistently applied reference standard	Cases (n =78) submitted from 15 centers in 4 countries had the following diagnoses	The aim of this study was to report the results of an international multicenter experience of cardiac magnetic resonance imaging (MRI) evaluation of cardiac tumors in children, each with histology correlation or a diagnosis of tuberous sclerosis, and to determine which characteristics are predictive of tumor type.	Fibroma (n = 30), rhabdomyoma (n = 14), malignant tumor (n = 12), hemangioma (n = 9), thrombus (n = 4), myxoma (n = 3), teratoma(n =2), and paraganglioma, pericardial cyst, Purkinje cell tumor, and papillary fibroelastoma (n = 1, each). Reviewers who were blinded to the histologic diagnoses correctly diagnosed 97% of the cases but included a differential diagnosis in 42%. Better image quality grade and more complete examination were associated with higher diagnostic accuracy.	2
Q48	Hong YJ, et al. The usefulness of delayed contrast-enhanced cardiovascular magnetic resonance imaging in differentiating cardiac tumors from thrombi in stroke patients. The international journal of cardiovascular imaging 2011; 27 Suppl 1:89-95	Individual cross sectional studies with consistently applied reference standard	22 patients	The objectives of this study were to evaluate the diagnostic value of delayed-enhancement cardiovascular magnetic resonance (DE-CMR) imaging in differentiating cardiac tumors from thrombi in patients with suspected cardio-embolic stroke.	On cine-CMR, the mean SI ratios for tumors and thrombi were 1.45 ± 0.45 (range, 1.12–2.16) and 1.39 ± 0.33 (range, 0.87–2.09), respectively (P =0.745). On DE-CMR, the mean SI ratios for tumors and thrombi were 5.65 ± 2.96 (range, 2.98–9.92) and 1.06 ± 0.43 (range, 0.67–1.95), respectively (P0.001). DE-CMR is a non-invasive modality for detecting intra-cardiac mass can differentiate tumors from thrombi in cardio-embolic stroke patients.	2
Q48	Motwani M, et al. MR imaging of cardiac tumors and masses: A review of	Review		We provide a detailed description of a core protocol for the MR assess-	Cardiac MR imaging features reliably detect thrombus and have been shown to accurately differentiate between benign and malignant tumors. A core protocol of MR	4

	methods and clinical applications. Radiology 2013;268:26-43			ment of cardiac masses and tumors and illustrate the different imaging characteristics of the most common types of mass, with case examples.	sequences as described in this review allows the morphology, anatomy, tissue characteristics, and functional impact of a suspected tumor to be assessed in a single examination.	
Q48	Weinsaft JW, et al. Contrast-enhanced anatomic imaging as compared to contrast-enhanced tissue characterization for detection of left ventricular thrombus. JACC. Cardiovascular imaging 2009; 2:969-979	Individual cross sectional studies with consistently applied reference standard	121 patients	This study sought to compare contrast-enhanced anatomic imaging and contrast enhanced tissue characterization (delayed-enhancement cardiac magnetic resonance [DE-CMR]) for left ventricular (LV) thrombus detection	Twenty-four patients had thrombus by DE-CMR. Patients with thrombus had larger infarcts (by DE-CMR), more aneurysms, and lower LV ejection fraction (by CMR and echo) than those without thrombus. Contrast echo nearly doubled sensitivity (61% vs. 33%, $p < 0.05$) and yielded improved accuracy (92% vs. 82%, $p < 0.01$) versus noncontrast echo. Patients who derived incremental diagnostic utility from DE-CMR had lower LV ejection fraction versus those in whom noncontrast echo alone accurately assessed thrombus (35 ± 9% vs. 42 ± 14%, $p < 0.01$), with a similar trend for patients who derived incremental benefit from contrast echo ($p=0.08$). Contrast echo and cine-CMR closely agreed on the diagnosis of thrombus ($k= 0.79$, $p < 0.001$). Thrombus prevalence was lower by contrast echo than DE-CMR ($p < 0.05$). Thrombus detected by DE-CMR but not by contrast echo was more likely to be mural in shape or, when apical, small in volume ($p < 0.05$).	2
Q49	Axel L. Assessment of pericardial disease by mag-	Review		Pericardial disease and its consequences can be well	MRI and CT can provide useful information for the evaluation of and treatment planning for pericardial disease,	4

	netic resonance and computed tomography. Journal of magnetic resonance imaging: JMRI 2004;19:816-826			shown with magnetic resonance imaging (MRI) and computed tomography (CT). Here I review the normal and pathologic anatomy and physiology of the pericardium, approaches to MRI and CT imaging of the pericardium, and some specific considerations in common conditions affecting the pericardium.	as well as revealing it as an incidental finding on studies performed for other indications. The normally thin pericardium is well seen on MRI and CT, and any pericardial thickening or increased fluid within the pericardial space is usually readily identified. While the morphologic findings are not always specific for etiology or sufficient by themselves to assess the clinical significance of pericardial thickening or effusions, ongoing advances in dynamic imaging may soon provide additional pathophysiologic information to aid in the detection and clinical management of possible pericardial tamponade or constriction.	
Q49	Francone M, et al. Assessment of ventricular coupling with real-time cine MRI and its value to differentiate constrictive pericarditis from restrictive cardiomyopathy. European radiology 2006;16:944-951	Studies without consistently applied reference standards	In 18 histologically proven cases of CP, 6 patients with inflammatory pericarditis (IP), 15 RCM patients and 17 normal subjects	The purpose of this study was to evaluate the use of respiratory-related ventricular coupling to differentiate patients with constrictive pericarditis (CP) and restrictive cardiomyopathy (RCM).	Real-time cine MRI can easily depict increased ventricular coupling, which may be helpful to better differentiate between CP and RCM patients, especially in patients with normal or minimally thickened pericardium. The increase in coupling in IP patients is likely caused by decreased compliance of the inflamed pericardial layers.	3

Q49	Mastouri R, et al. Noninvasive imaging techniques of constrictive pericarditis. Expert review of cardiovascular therapy 2010; 8:1335-1347	Review		Constrictive pericarditis (CP) is the result of scarring and loss of elasticity of the pericardial sac, resulting in external impedance of cardiac filling. It can occur after virtually any pericardial disease process. Patients typically present with signs and symptoms of right heart failure and/or low cardiac output.	An important pathophysiological hallmark of CP is exaggerated ventricular interdependence and impaired diastolic filling. Echocardiography is the initial imaging modality for diagnosis of CP. Unfortunately, no echocardiographic sign or combination of signs is pathognomonic for CP. CT scan and cardiac MRI are other imaging techniques that can provide incremental diagnostic information. CT scan can easily detect pericardial thickening and calcification, while cardiac MRI provides a comprehensive evaluation of the pericardium, myocardium and cardiac physiology. Occasionally, a multimodality approach needs to be considered for the conclusive diagnosis of CP.	4
Q50	Shiga T, et al. Diagnostic accuracy of transesophageal echocardiography, helical computed tomography, and magnetic resonance imaging for suspected thoracic aortic dissection: Systematic review and meta-analysis (structured abstract).Archives of Internal Medicine 2006; 166:1350-1356	Systematic Review and Meta-analysis	Sixteen studies involving a total of 1139 patients were selected	We systematically reviewed the diagnostic accuracy of these imaging techniques in patients with suspected thoracic aortic dissection.	Pooled sensitivity (98%-100%) and specificity (95%-98%) were comparable between imaging techniques. The pooled positive likelihood ratio appeared to be higher for MRI (positive likelihood ratio, 25.3; 95% confidence interval, 11.1-57.1) than for TEE (14.1; 6.0-33.2) or helical CT (13.9; 4.2-46.0). If a patient had shown a 50% pretest probability of thoracic aortic dissection (high risk), he or she had a 93% to 96% posttest probability of thoracic aortic dissection following a positive result of each imaging test. If a patient had a 5% pretest probability of thoracic aortic dissection (low risk), he or she had a 0.1% to 0.3% posttest probability of thoracic aortic dissection following a negative result of each imaging test.	1

Q51	Kato R, et al. Pulmonary vein anatomy in patients undergoing catheter ablation of atrial fibrillation: Lessons learned by use of magnetic resonance imaging. Circulation 2003;107:2004-2010	Studies without consistently applied reference	Twenty-eight patients	This study sought to define the technique and results of magnetic resonance imaging (MRI) of pulmonary vein (PV) anatomy before and after catheter ablation of atrial fibrillation (AF).	Variant PV anatomy was observed in 38% of patients. AF patients had larger PV diameters than control subjects, but no difference was observed in the size of the PV ostia among AF patients. The PV ostia were oblong in shape with an anteroposterior dimension less than the superoinferior dimension. The left PVs had a longer "neck" than the right PVs. A detectable PV narrowing was observed in 24% of veins. The severity of stenosis was severe in 1 vein (1.4%), moderate in 1 vein (1.4%), and mild in 15 veins (21.1%). All patients were asymptomatic, and none required treatment.	3
Q51	Lacomis JM, et al. Direct comparison of computed tomography and magnetic resonance imaging for characterization of posterior left atrial morphology. Journal of interventional cardiac electrophysiology : an international journal of arrhythmias and pacing 2006;16:7-13	Studies with consistently applied reference standards	Twenty patients	Accumulating evidence points to the central importance of the posterior left atrium (PLA) for atrial fibrillation (AF). Catheter ablation intended to cure AF is increasingly practiced; performance and assessment of this procedure is enhanced by accurate imaging of PLA anatomy. Prior reports have suggested that both computed tomographic (CT) and magnetic resonance	Twenty patients referred for catheter ablation underwent preoperative imaging using both CT and MR. Each technique was used to create a multidimensional image of the PLA. RESULTS: Within patients, morphologic and dimensional PLA indices, including number of individual pulmonary venoatrial junctions, presence of ostial branches, circumference of each venoatrial junction, venoatrial junction "non-circularity", and distance between ipsilateral superior and inferior venoatrial junctions, were well correlated.	2

				(MR) imaging techniques provide accurate PLA images. These techniques have never been compared directly.		
Q51	Mansour M, et al. Three-dimensional anatomy of the left atrium by magnetic resonance angiography: Implications for catheter ablation for atrial fibrillation. Journal of cardiovascular electrophysiology 2006;17:719-723	Case series	Fifty consecutive patients	A detailed anatomical characterization of these regions has not been previously reported.	The width of the ridge separating the LPV from the LAA was found to be 3.7 +/- 1.1 mm at its narrowest point. The segment of this ridge with a width of 5 mm or less was 16.6 +/- 6.4 mm long. The width of the ridges separating the RMPV from the RSPV and the RIPV was found to be 3.0 +/-1.5 mm and 3.1 +/-1.8 mm, respectively. There were no significant differences between LPV ridges for patients with versus without a RMPV.	4
Q52	Thomson LE, et al. Direct en face imaging of secundum atrial septal defects by velocity-encoded cardiovascular magnetic resonance in patients evaluated for possible transcatheter closure. Circulation. Cardiovascular imaging 2008;1:31-40	Case series	Forty-four patients	Imaging the secundum ASD en face could potentially enable direct flow measurement and provide valuable information about ASD size, shape, location, and proximity to other structures.	En face veCMR with an optimized imaging plane can determine ASD flow, size, and morphology. CMR provided information incremental to comprehensive standard evaluation that altered clinical management in 20% of patients.	4

Q52	Weber C, et al. Atrial septal defects type ii: Noninvasive evaluation of patients before implantation of an amplatzer septal occluder and on follow-up by magnetic resonance imaging compared with tee and invasive measurement. European radiology 2008;18:2406-2413	Individual cross sectional studies with consistently applied reference standard	Sixty patients	The purpose of this study was to evaluate morphological and functional MRI of atrial septal defects (ASD) before and after interventional occlusion by the Amplatzer Septal Occluder (AOC) in comparison to transoesophageal echocardiography (TEE), invasive balloon measurement (IVBM) and cardiac catheterization (QCC).	Correlation between defect size in MRI vs. TEE was R=0.67 (P<0.01) and MRI vs. IVBM was R=0.77 (P<0.01). Right ventricular volumes decreased after intervention. MRI is an accurate noninvasive test for diagnosis, planning and follow-up after interventional ASD occlusion using an AOC.	2
Q52	La Manna A, et al. Cardiovascular magnetic resonance for the assessment of patients undergoing transcatheter aortic valve implantation: A pilot study." Journal of cardiovascular magnetic resonance : official journal of the Society for Cardiovascular Magnetic Resonance 2011;13:82	Individual cross sectional studies with consistently applied reference standard	Patients who underwent both TTE and CMR (n = 49)	The aim of this study was to compare cardiovascular magnetic resonance (CMR) and trans-thoracic echocardiography (TTE) for the assessment of aortic valve measurements and left ventricular function in high-risk elderly patients submitted to TAVI.	CMR generally tended to report larger values than TTE for all measurements. The Bland-Altman test indicated that the 95% limits of agreement between TTE and CMR ranged from -5.6 mm to + 1.0 mm for annulus size, from -0.45 mm to + 0.25 mm for LVOT, from -0.45 mm2 to + 0.25 mm2 for AVA and from -29.2% to 13.2% for LVEF.	2