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Invasive coronary angiogram (ICA) vs. computed tomography angiogram (CTA) in diagnosing coronary artery disease (CAD)

Tarek Chami, MD
Interventional Cardiology Fellow
Allina Health Minneapolis Heart Institute

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Complimentary role of coronary computed tomography angiogram (CTA) in patients with coronary artery disease (CAD)

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Disclosure

- I have nothing to disclose except that I am a plumber interested in the intersection between noninvasive and invasive imaging

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Objectives

Review the utility of cCTA in patients with chest pain

Explore the emerging roles of cCTA in patients with:

- NSTE-ACS
- Known CAD

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Case

77-year-old man with CAD who underwent CABG (LIMA-LAD,VG-OM) and bioprosthetic AVR (25mm Inspiris) almost 2 years ago, was referred for coronary angiogram for DOE “angina equivalent” and abnormal cCTA

- PMH/PSH
  - Recent Stroke (2 months prior): LUE weakness, dizziness
  - PAD
  - HTN, DLD, H/O Tob use d/o

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cCTA

- Atretic/occluded LIMA graft to the LAD.
- Patent aortic graft to the OM1.
- Obstructive native multivessel coronary disease, including:
  - occlusion of the proximal LCX
  - severe stenosis in the ramus intermedius artery
  - >70% diameter stenosis in the proximal RCA
- #Compared to catheter coronary angiography (done before AVR and CABG):
- There has interval bypass grafts to the LAD and OM1.
- The proximal RCA disease appears more severe today

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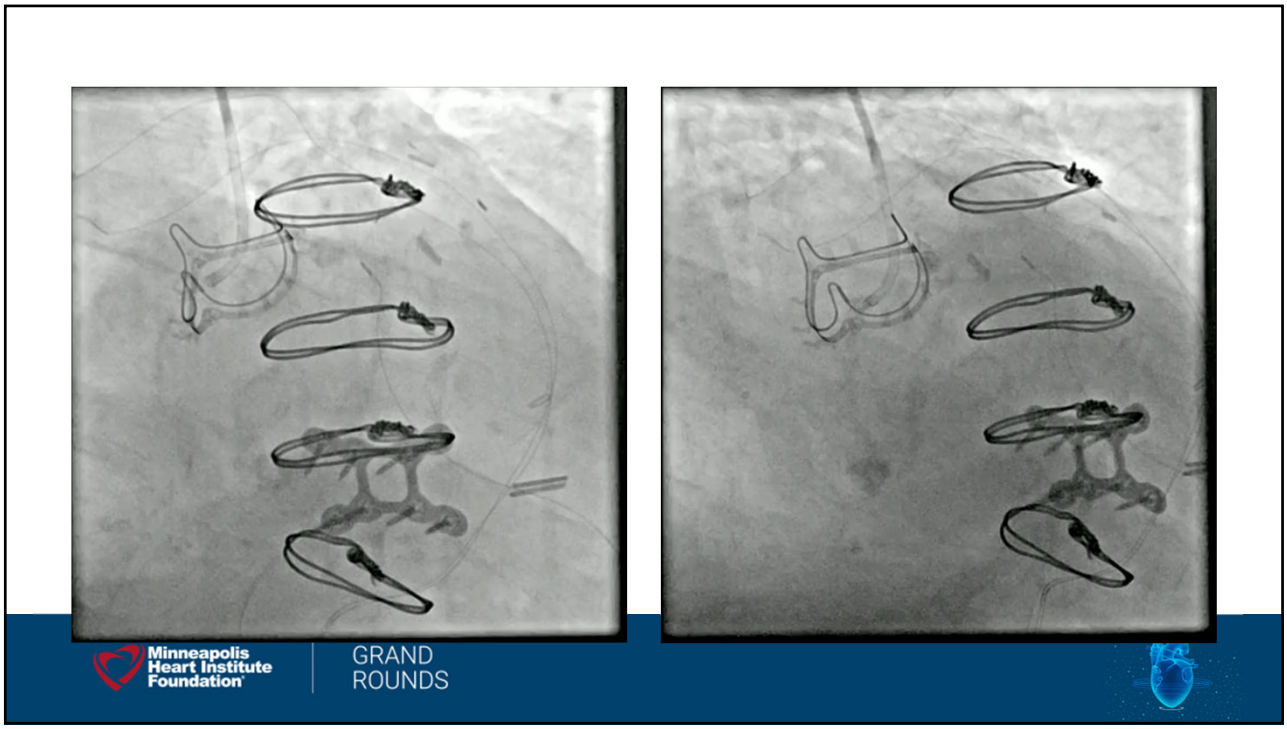
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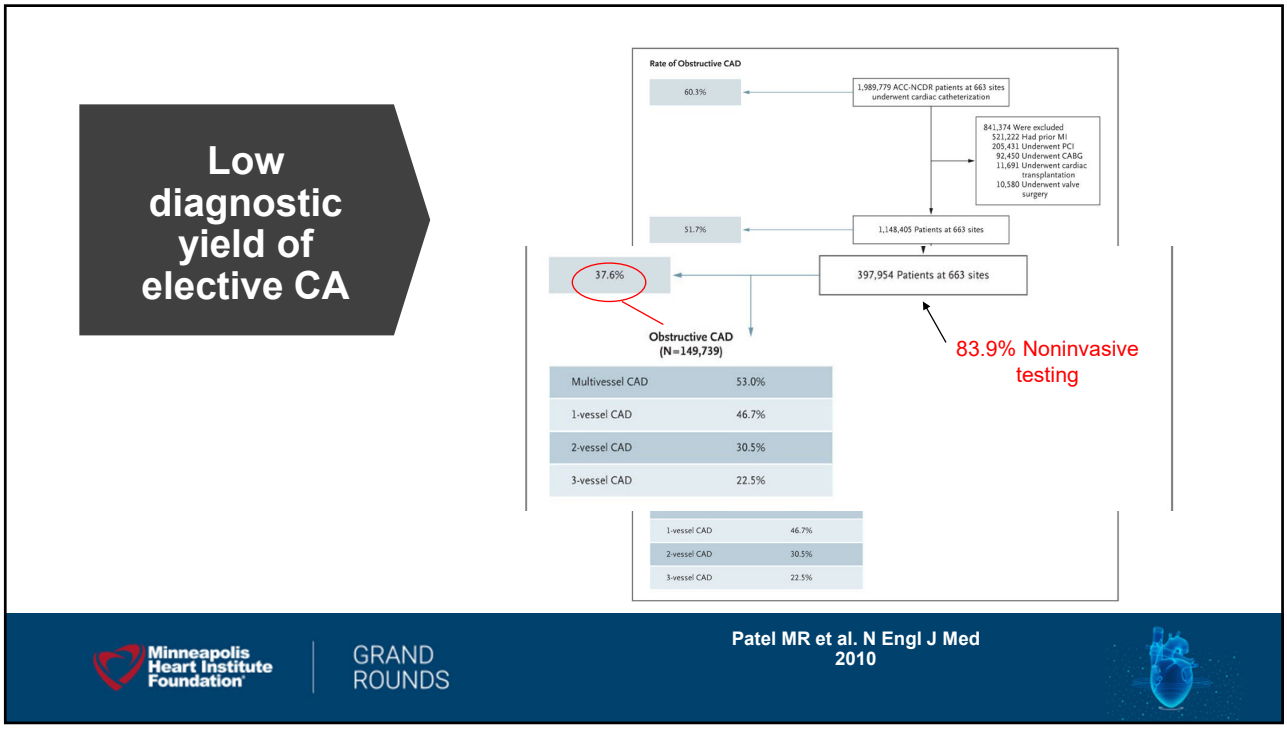
Low diagnostic yield of elective CA
Rate of Obstructive CAD
60.3%
1,989,779 ACC-NCDR patients at 663 sites underwent cardiac catheterization
841,374 Were excluded
521,222 Had prior MI
205,431 Underwent PCI
92,450 Underwent CABG
11,691 Underwent cardiac transplantation
10,580 Underwent valve surgery
51.7%
1,148,405 Patients at 663 sites
37.6%
397,954 Patients at 663 sites
Obstructive CAD (N=149,739)
83.9% Noninvasive testing
Multivessel CAD 53.0%
1-vessel CAD 46.7%
2-vessel CAD 30.5%
3-vessel CAD 22.5%
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Patel MR et al. N Engl J Med 2010

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30-days adverse events after CTA vs ICA (CORE 320)

Table 2 Serious adverse events and adverse events

	Number of patients
CT associated serious adverse events	
Renal failure	0
Reaction to contrast dye	3
Transient heart block	2
Hypotension	1
Extravasation of contrast agent in the antecubital fossa	1
Pulmonary edema[a]	1
Vagal episode	1
Cardiovascular events	
Death	0
Myocardial infarction[b]	2
Stroke	0
Hospitalization for CV event	4
Coronary dissection[c]	2
Chest pain[d]	2
Femoral artery pseudo-aneurism (vascular event)[e]	1
Intracerebral bleeding/infarct[f]	1

CT, computed tomography angiography; CV, cardiovascular.
[a]Pulmonary edema: patient had CHF exacerbation after the CT scan.
[b]Myocardial infarction: one patient had MI after PCI and one 5 months later.
[c]Coronary dissections were as follows: A 59-year-old female had a dissection during diagnostic catheterization and a 71-year-old male had dissection during PCI.
[d]Chest pain: one non-cardiac and one occurred after the CT examination.
[e]Femoral artery pseudo-aneurism: vascular access complication.
[f]Intracerebral bleeding/infarct detected 24 h post-cardiac catheterization.

Total 381 pts

Rochitte C et al. EHJ 2013

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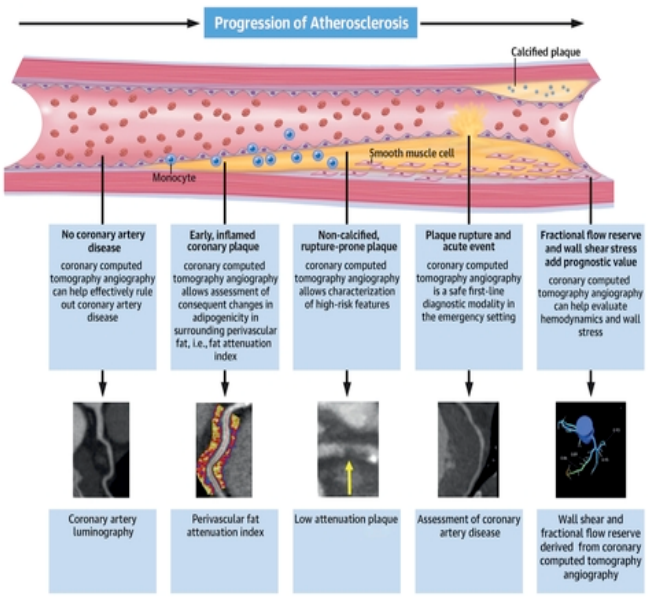
CENTRAL ILLUSTRATION: Utility of Coronary Computed Tomography Angiography in Coronary Artery Disease



Abdelrahman, K.M. et al. J Am Coll Cardiol. 2020;76(10):1226-43.

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NPV of cCTA (ACCURACY)

Table 2 Patient-Based Analysis

	Estimate, %	95% CI, %	Subjects in Group, n	Subjects Correct by CCTA, n
≥50% stenosis				
Sensitivity	95	85–99	55	52
Specificity	83	76–88	172	142
PPV	64	53–75	81	52
NPV	99	96–100	143	142
≥70% stenosis				
Sensitivity	94	79–99	31	29
Specificity	83	77–88	196	162
PPV	48	35–62	60	29
NPV	99	96–100	164	162

Budoff M et al. JACC 2008

cCTA highest sensitiv for ruling out CAD

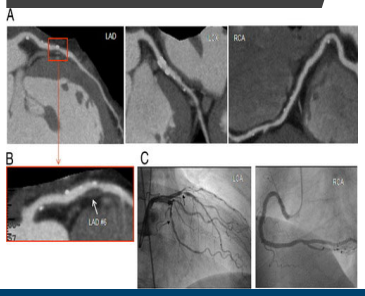
Table 1 The performance of different tests for anatomically and functionally significant coronary artery disease

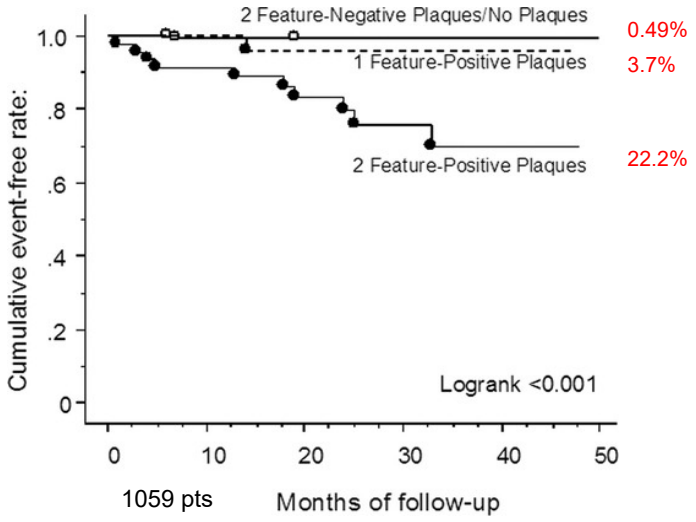
Anatomically significant CAD					Functionally significant CAD				
Test	Sensitivity (%), (95% CI)	Specificity (%), (95% CI)	+LR (95% CI)	−LR (95% CI)	Test	Sensitivity (%), (95% CI)	Specificity (%), (95% CI)	+LR (95% CI)	−LR (95% CI)
					ICA	68 (60–75)	73 (55–86)	2.49 (1.47–4.21)	0.44 (0.36–0.54)
Stress ECG	58 (46–69)	62 (54–69)	1.53 (1.21–1.94)	0.68 (0.49–0.93)					
Stress echo	85 (80–89)	82 (72–89)	4.67 (2.95–7.41)	0.18 (0.13–0.25)					
CCTA	97 (93–99)	78 (67–86)	4.44 (2.64–7.45)	0.04 (0.01–0.09)	CCTA	93 (89–96)	53 (37–68)	1.97 (1.28–3.03)	0.13 (0.06–0.25)
SPECT	87 (83–90)	70 (63–76)	2.88 (2.33–3.56)	0.19 (0.15–0.24)	SPECT	73 (62–82)	83 (71–90)	4.21 (2.62–6.76)	0.33 (0.24–0.46)
PET	90 (78–96)	85 (78–90)	5.87 (3.40–10.15)	0.12 (0.05–0.29)	PET	89 (82–93)	85 (81–88)	6.04 (4.29–8.51)	0.13 (0.08–0.22)
Stress CMR	90 (83–94)	80 (69–88)	4.54 (2.37–8.72)	0.13 (0.07–0.24)	Stress CMR	89 (85–92)	87 (83–91)	7.10 (5.07–9.95)	0.13 (0.09–0.18)

Note: ICA itself was used as a reference standard for the anatomically significant CAD estimates but was included as a technique when FFR was used as the reference. Not every test had enough data using FFR as reference.
CCTA, coronary computed tomography angiography; CI, confidence interval; CMR, stress cardiac magnetic resonance; ECG, electrocardiogram; ICA, invasive coronary angiography; LR, likelihood ratio; PET, positron emission tomography; SPECT, single-photon emission computed tomography (exercise stress SPECT with or without dipyridamole or adenosine); Stress echo, exercise stress echocardiography.

Knuuti J et al. *Eur Heart J 2018*

PR, LAP on cCTA is associated with future ACS





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Motoyama S et al. *J Am Coll Cardiol* 2009

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cCTA →↑ ICA, Revasc, CAD dx and use of ASA, Statin

Table 2. Summary of Findings[a]

Outcome	Illustrative Comparative Risks, No. per 1000[b] Assumed Risk (SC)	Corresponding Risk (CCTA) (95% CI)	RR (95% CI)	No. of Participants (No. of Studies)	Quality of Evidence[c]
Death	11	10 (8-14)	0.93 (0.71-1.21)	20 092 (13)	Moderate
Acute chest pain subgroup	3	2 (1-5)	0.66 (0.27-1.59)	5275 (9)	Moderate
Stable chest pain subgroup	13	12 (9-17)	0.96 (0.72-1.27)	14 817 (4)	Moderate
Myocardial infarction	11	8 (6-11)	0.71 (0.53-0.96)	20 092 (13)	Moderate
Acute chest pain subgroup	8	7 (4-13)	0.84 (0.44-1.61)	5275 (9)	Moderate
Stable chest pain subgroup	11	7 (5-10)	0.68 (0.49-0.95)	14 817 (4)	Moderate
Cardiac hospitalization	27	27 (21-33)	0.98 (0.79-1.21)	19 401 (12)	Moderate
Acute chest pain subgroup	63	52 (42-66)	0.83 (0.66-1.04)	4584 (8)	Moderate
Stable chest pain subgroup	17	21 (16-26)	1.21 (0.96-1.53)	14 821 (4)	Moderate
Invasive coronary angiography	91	121 (102-155)	1.33 (1.12-1.59)	20 092 (13)	Moderate
Acute chest pain subgroup	72	100 (79-127)	1.39 (1.10-1.76)	5275 (9)	Moderate
Stable chest pain subgroup	98	125 (94-167)	1.27 (0.96-1.70)	14 817 (4)	Moderate
Revascularization	45	84 (64-109)	1.86 (1.43-2.43)	20 092 (13)	High
Acute chest pain subgroup	28	55 (41-74)	1.96 (1.45-2.65)	5275 (9)	High
Stable chest pain subgroup	51	87 (57-133)	1.70 (1.12-2.60)	14 817 (4)	Moderate
Coronary artery disease diagnosis	83	232 (169-321)	2.80 (2.03-3.87)	8793 (9)	High
Acute chest pain subgroup	50	169 (96-295)	3.37 (1.92-5.89)	3979 (6)	High
Stable chest pain subgroup	107	251 (162-392)	2.35 (1.51-3.66)	4814 (3)	High
Therapeutic change—aspirin	82	181 (98-331)	2.21 (1.20-4.04)	5625 (5)	Low
Acute chest pain subgroup	249	316 (247-401)	1.27 (0.99-1.61)	811 (2)	Low
Stable chest pain subgroup	54	189 (145-245)	3.50 (2.69-4.54)	4814 (3)	Low
Therapeutic change—statin	73	148 (80-275)	2.03 (1.09-3.76)	5625 (5)	Low
Acute chest pain subgroup	190	230 (177-300)	1.21 (0.93-1.58)	811 (2)	Low
Stable chest pain subgroup	53	184 (139-244)	3.48 (2.63-4.61)	4814 (3)	Low

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Foy A et al. JAMA Intern Med 2017

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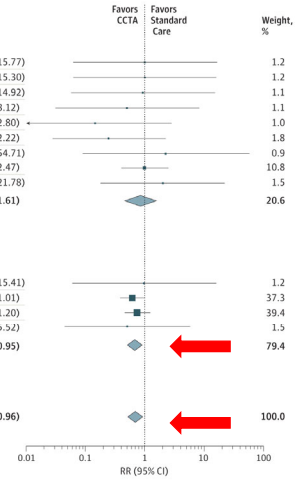
cCTA → ↓incidence of MI

Study	CCTA No. of Events	CCTA Total Participants	Standard Care No. of Events	Standard Care Total Participants	RR (95% CI)	Weight, %
Acute						
Goldstein et al,[11] 2007	1	101	1	101	1.00 (0.06-15.77)	1.2
Miller et al,[13] 2011	1	32	1	32	1.00 (0.07-15.30)	1.2
Goldstein et al (CT-STAT),[12] 2011	1	363	1	340	0.94 (0.06-14.92)	1.1
ACRIN/PA,[2] 2012	1	908	1	462	0.51 (0.03-8.12)	1.1
Linde et al (CATCH),[15] 2013	0	286	3	291	0.15 (0.01-2.80)	1.0
Hoffman et al (ROMICAT-II),[3] 2012	1	501	4	499	0.25 (0.03-2.22)	1.8
Hamilton-Craig et al (CT-COMPARE),[16] 2014	1	322	0	240	2.24 (0.09-54.71)	0.9
PROSPECT,[17] 2015	9	200	9	200	1.00 (0.41-2.47)	10.8
Uretsky et al (PERFECT),[20] 2016	2	206	1	205	1.99 (0.18-21.78)	1.5
Subtotal (95% CI)		**2919**		**2370**	**0.84 (0.44-1.61)**	**20.6**
Total events	**17**		**21**			
Heterogeneity: $\tau^2=0.00$; $\chi^2_6=3.76$; $P=.88$; $I^2=0\%$ Test for overall effect: $z=0.52$ ($P=.60$)						
Stable						
Min et al,[14] 2012	1	93	1	91	0.98 (0.06-15.41)	1.2
SCOT-HEART,[21] 2015	26	2073	42	2073	0.62 (0.38-1.01)	37.3
Douglas et al (PROMISE),[18] 2015	30	4996	40	5007	0.75 (0.47-1.20)	39.4
McKavanagh et al (CAPP),[19] 2015	1	243	2	245	0.50 (0.05-5.52)	1.5
Subtotal (95% CI)		**7405**		**7416**	**0.68 (0.49-0.95)**	**79.4**
Total events	**58**		**85**			
Heterogeneity: $\tau^2=0.00$; $\chi^2_3=0.44$; $P=.93$; $I^2=0\%$ Test for overall effect: $z=2.24$ ($P=.02$)						
Total (95% CI)		**10324**		**9786**	**0.71 (0.53-0.96)**	**100.0**
Total events	**75**		**106**			
Heterogeneity: $\tau^2=0.00$; $\chi^2_{13}=4.46$; $P=.97$; $I^2=0\%$ Test for overall effect: $z=2.24$ ($P=.03$) Test for subgroup differences: $\chi^2_1=0.31$; $P=.58$; $I^2=0\%$						



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Foy A et al. *JAMA* Intern Med 2017

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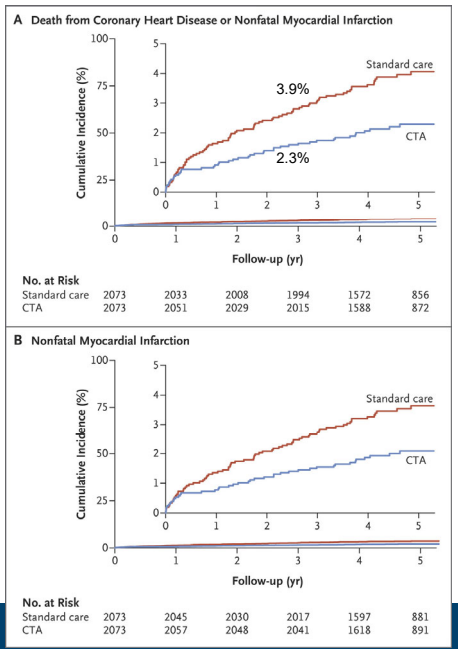
cCTA +MedRx → ↓ death from CHD or nonfatal MI at 5 years



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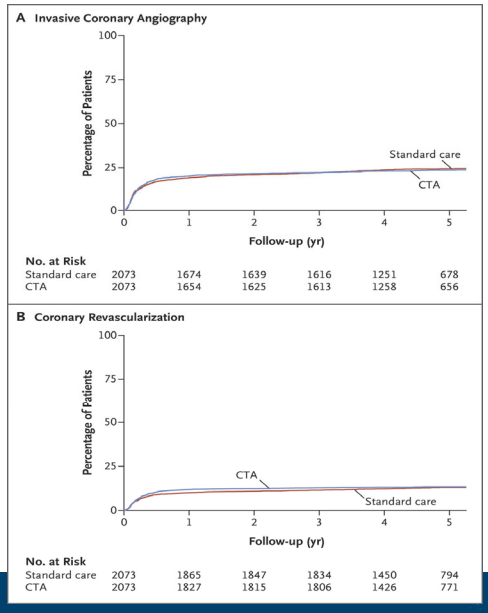
The SCOT-HEART Investigators. N Engl J Med 2018

18

cCTA vs SC: No difference in ICA, Revasc at 5 years



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The SCOT-HEART Investigators. N Engl J Med 2018

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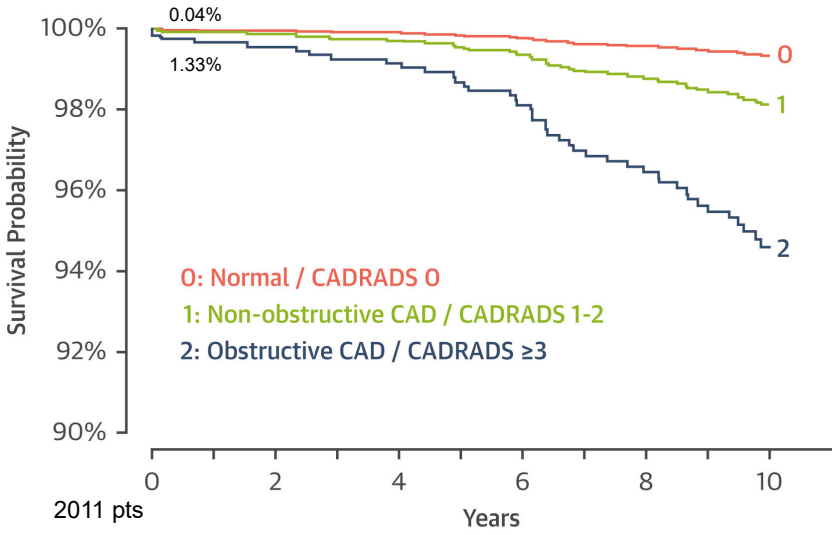
Normal cCTA→ 10 yrs guarantee (cardiac death, nonfatal MI)



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Finck T et al. *JACC Cardiovasc Img* 2019

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ESC Guidelines 2019

Non-invasive functional imaging for myocardial ischaemia[c] or coronary CTA is recommended as the initial test to diagnose CAD in symptomatic patients in whom obstructive CAD cannot be excluded by clinical assessment alone.[4,5,55,73,78–80]	I	B
It is recommended that selection of the initial non-invasive diagnostic test is done based on the clinical likelihood of CAD and other patient characteristics that influence test performance,[d] local expertise, and the availability of tests.	I	C
Functional imaging for myocardial ischaemia is recommended if coronary CTA has shown CAD of uncertain functional significance or is not diagnostic.[4,55,73]	I	B
Invasive coronary angiography is recommended as an alternative test to diagnose CAD in patients with a high clinical likelihood, severe symptoms refractory to medical therapy or typical angina at a low level of exercise, and clinical evaluation that indicates high event risk. Invasive functional assessment must be available and used to evaluate stenoses before revascularization, unless very high grade (>90% diameter stenosis).[71,72,74]	I	B
Invasive coronary angiography with the availability of invasive functional evaluation should be considered for confirmation of the diagnosis of CAD in patients with an uncertain diagnosis on non-invasive testing.[71,72]	IIa	B
Coronary CTA should be considered as an alternative to invasive angiography if another non-invasive test is equivocal or non-diagnostic.	IIa	C
Coronary CTA is not recommended when extensive coronary calcification, irregular heart rate, significant obesity, inability to cooperate with breath-hold commands, or any other conditions make obtaining good image quality unlikely.	III	C
Coronary calcium detection by CT is not recommended to identify individuals with obstructive CAD.	III	C

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Knuuti J et al. Eur Heart J 2020

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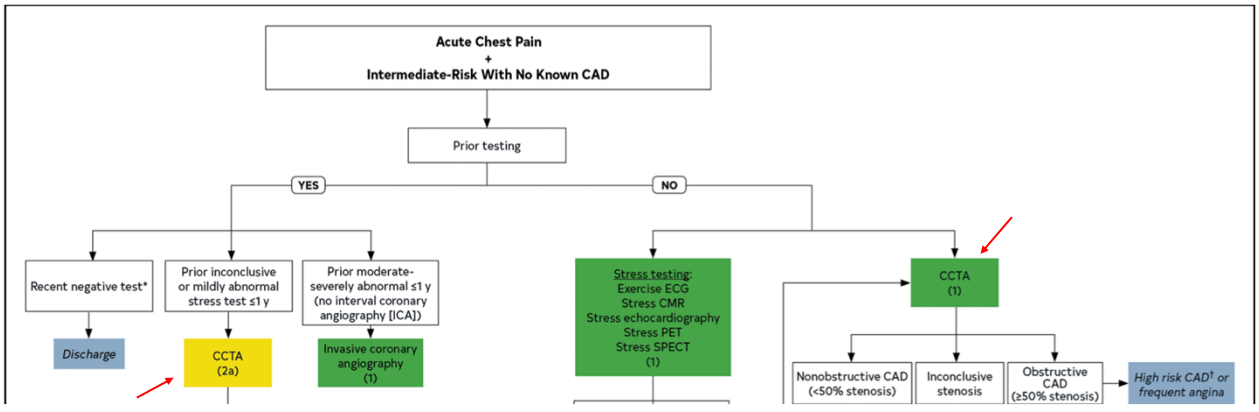
2021 AHA/ACC/ASE/CHEST/SAEM/SCCT/ SCMR Guidelines



Martha Gulati et al. Circulation. 2021

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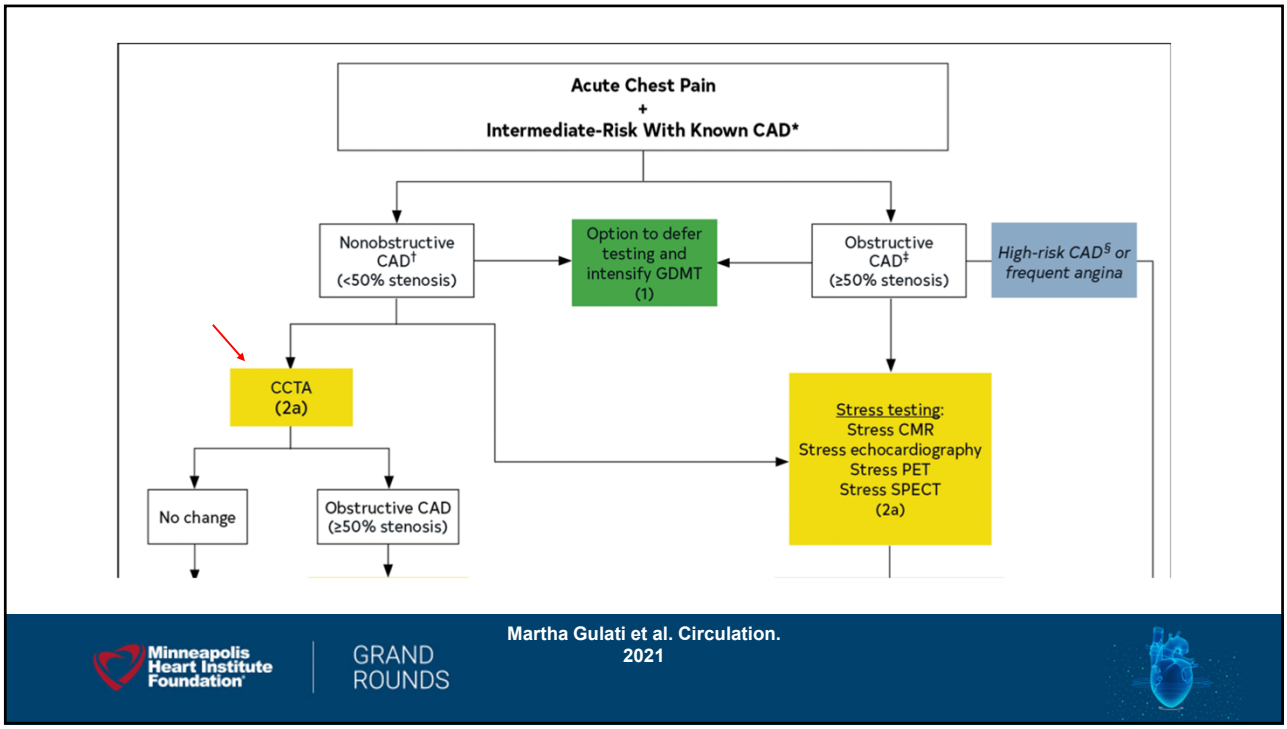

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Emerging roles of CTA

Role of cCTA in patient with NSTE-ACS

Role of cCTA in patient with known CAD

- Prior CABG
- Prior Stent
- CTO
- Multivessels

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≃ 30% of pts with CP + HST→ Nonobstruct CAD

TABLE 2 In-Hospital Course

	hs-cTnT				
	<6 ng/l (n = 5,790)	6-13 ng/l (n = 6,491)	14-49 ng/l (n = 10,476)	≥50 ng/l (n = 25,837)	p Value
Coronary angiography	1,419	2,247	4,808	18,017	
Nonconclusive	2 (0.1)	8 (0.4)	19 (0.4)	59 (0.3)	0.533
Normal/atheromatosis	806 (56.8)	876 (39.0)	1,373 (28.6)	2,157 (12.0)	<0.001
1-2 VD	456 (32.1)	924 (41.1)	2,222 (46.2)	10,684 (59.3)	<0.001
LM or 3 VD	155 (10.9)	439 (19.5)	1,194 (24.8)	5,117 (28.4)	<0.001

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Melki D et al. *J Am Coll Cardiol* 2015

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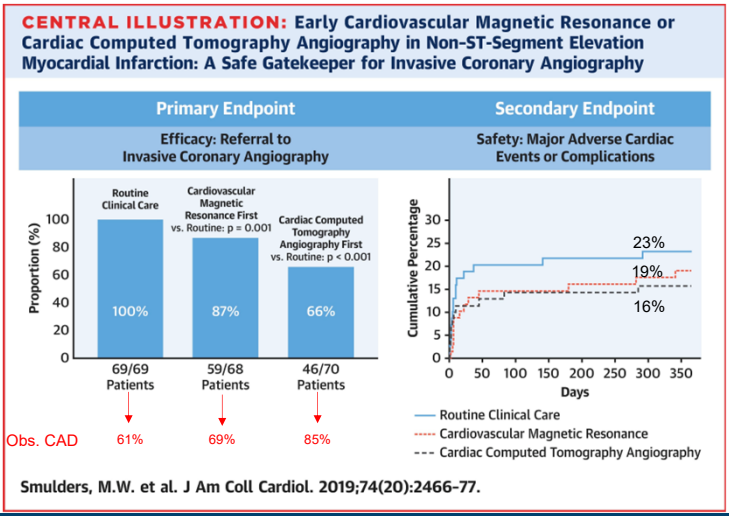
Initial CMR/CTA vs SC→ ↓ ICA but similar MACE/Complications

CENTRAL ILLUSTRATION: Early Cardiovascular Magnetic Resonance or Cardiac Computed Tomography Angiography in Non-ST-Segment Elevation Myocardial Infarction: A Safe Gatekeeper for Invasive Coronary Angiography



Smulders, M.W. et al. J Am Coll Cardiol. 2019;74(20):2466-77.

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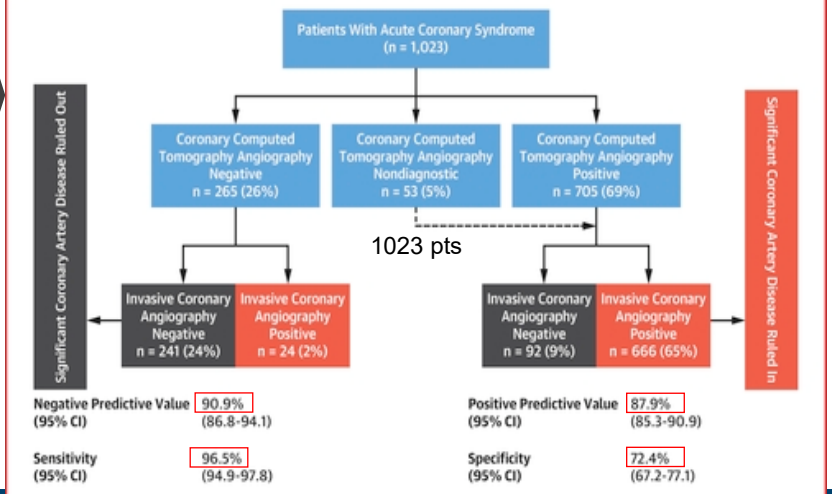
Diagnostic accuracy of cCTA in NSTE-ACS

CENTRAL ILLUSTRATION: Diagnostic Accuracy of Coronary Computed Tomography Angiography Using Invasive Coronary Angiography as Reference Standard



Linde, J.J. et al. J Am Coll Cardiol. 2020;75(5):453-63.

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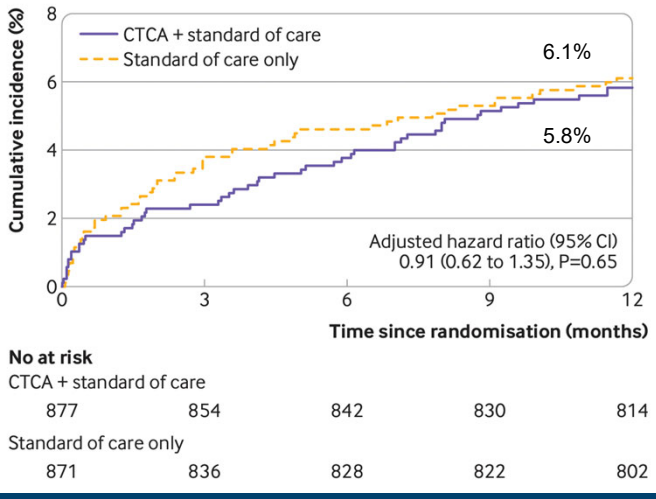
1-yr clinical outcomes (RAPID-CTA)



Gray AJ et al. BMJ 2021

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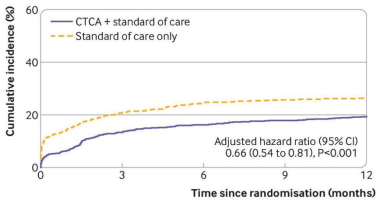
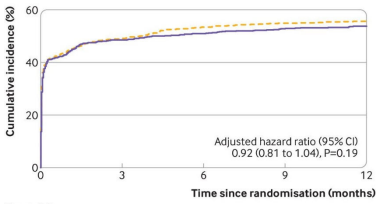
1-yr clinical outcomes (RAPID-CTA)



60.8%
54%

No at risk

CTCA + standard of care	875	751	723	703	679
Standard of care only	870	679	647	632	614



No at risk

CTCA + standard of care	877	448	426	406	393
Standard of care only	870	440	401	386	374

Table 4 | Medical treatment and other outcomes

	CT coronary angiography and standard of care (n=877)	Standard of care only (n=871)	Estimate	Odds ratio (95% CI)	P value
Inhospital medical treatment for acute coronary syndrome	595 (67.8)	580 (66.6)	Unadjusted	1.06 (0.87 to 1.29)	0.58
			Adjusted	1.06 (0.85 to 1.32)	0.63
Change in preventive treatment	554 (63.2)	539 (61.9)	Unadjusted	1.06 (0.87 to 1.28)	0.58
			Adjusted	1.07 (0.87 to 1.32)	0.52
Preventive treatment:					
Started	526 (60.0)	509 (58.4)	—	—	—
Stopped	71 (8.1)	61 (7.0)	—	—	—
Dose changed	91 (10.4)	100 (11.5)	—	—	—

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Gray AJ et al. BMJ 2021

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2014 AHA/ACC NSTE-ACS Guideline

3. In patients with possible ACS and a normal ECG, normal cardiac troponins, and no history of CAD, it is reasonable to initially perform (without serial ECGs and troponins) coronary CT angiography to assess coronary artery anatomy[205–207] (*Level of Evidence: A*)

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Amsterdam et al. Circ 2014

30

CABG

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Accuracy of CTA in grafts (contemporary CT)

Table 1 Diagnostic performance of contemporary CT technology for coronary artery bypass graft evaluation

Author	Year	CT technology	Cases (*n*)	Grafts	Arterial/venous grafts (*n*)	Se (%)	Sp (%)	PPV (%)	NPV (%)	Radiation dose
Koplay [29]	2016	128-slice DSCT	45	110	40/70	90	99	90	99	1.83 ± 0.89 mSv
Yuceler [30]	2014	128-slice DSCT	88	215	93/122	93	100	87	100	2.5 ± 0.6 mSv
Chaosuwannakit [31]	2014	128- slice DSCT	54	164	52/112	100	98	91	100	Not reported
De Graaf [32]	2011	320-slice SSCT	38	89	28/61	96	92	83	98	7.8 ± 3.3 mSv

DSCT dual source computed tomography, *SSCT* single source CT, *Se* sensitivity, *Sp* specificity, *PPV* positive predictive value, *NPV* negative predictive value, *mSv* millisievert

Jubran A et al. Current Cardiovascular Imaging Reports 2019

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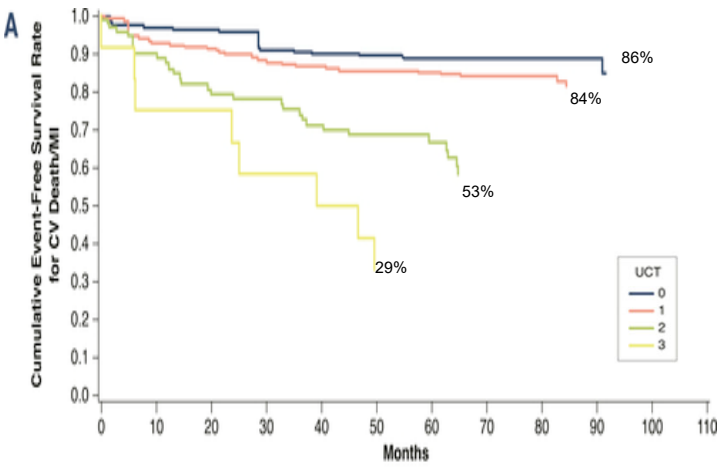
Prognostic value of CTA in CABG

700 pts
Mean follow up 73 month



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Mushtaq S et al. *J Am Coll Cardiol Img* 2014

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ISR

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CTA in ISR

100 pts with 192 stents

Table 3
Evaluability and diagnostic accuracy of CCTA in relation to stent characteristics during imaging, using only evaluable stents for analysis.

Stent characteristics	N	Evaluability (%)	TP	TN	FP	FN	Sn (%)	Sp (%)	PPV (%)	NPV (%)	Accuracy (%)
Stent diameter (mm)											
<3.0	72	91.6 (82.6–96.8)	10	45	11	1	90.1 (58.7–99.7)	80.3 (67.6–89.7)	47.6 (27.7–70.2)	97.8 (88.5–99.9)	82.1 (71.3–90.1)
≥3.0	120	96.8 (91,9–99.2)*	12	100	4	1	92.3 (63.9–99.8)	96.1 (90.4–98.9)*	75 (47.6–99.9)	99.1 (94.6–99.9)	95.7 (90.3–98-6)*
Strut thickness (μm)											
<100	92	96.7 (90.7–99.3)	14	68	7	1	93.3 (68.1–99.8)	90.7 (81.7–96.2)	66.7 (43.1–85.4	98.6 (92.2–99.9)	91.1 (83.3–96.1)
≥100	100	95 (88.7–98.4)	8	77	8	1	88.9 (51.7–99.7)	90.6 (82.3–95.8)	50 (24.65–75.3)	98.7 (93.1–99.9)	90.4 (82.9–95.4)
Stent material											
Stainless steel	101	96 (90.1–98.9)	9	76	12	2	81.8 (48.2–97.7)	86.4 (77.4–92.7)	42.8 (21.8–65.9)	97.4 (91.1–99.7)	85.8 (77.4–91.5)
Cobalt-chromium	91	95.6 (89,1–98.8)	13	69	3	0	100 (75.3–100)	95.8 (88.3–99.1)[¥]	81.2 (54.3–95.9)[¥]	100 (94.8–100)	95.5 (88.9–98.7)[¥]

Table 4
Diagnostic accuracy in a stent-based analysis of CCTA for the detection of significant (>50%) in-stent restenosis in the overall population.

All population	N	TN	TP	FN	FP	Sn (95% CI)	Sp (95% CI)	NPV (95% CI)	PPV (95% CI)	Accuracy (95% CI)
Stent-based analysis (using evaluable stents only)	184	145	22	2	15	91.7 (73–98.9)	90.6 (85–94.7)	98.6 (95.2–99.8)	59.5 (42.1–75.3)	90.7 (85.5–94.5)
Stent-based analysis (using all stents, with not evaluable stents censored as positive)	192	145	24	2	21	92.3 (74.9–99.1)	87.3 (81.3–92)	98.6 (95.2–99.8)	53.3 (37.9–68.3)	88 (82.5–92.2)

FN: false negative; FP: false positive; NPV: negative predictive value; PPV: positive predictive value; Sn: sensitivity; Sp: specificity; TN: true negative; TP: true positive.

Andreini D et al. Int J Cardiol 2018

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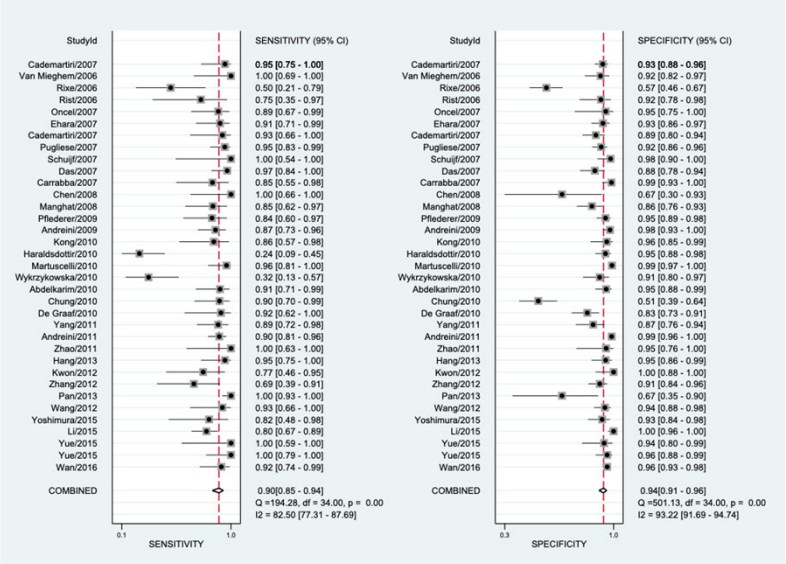
Diagnostic performance of CTA in ISR

35 studies (total of 2656 patients and 4131 stents)

Sens: 90% Spec: 94%

AUC: 0.97



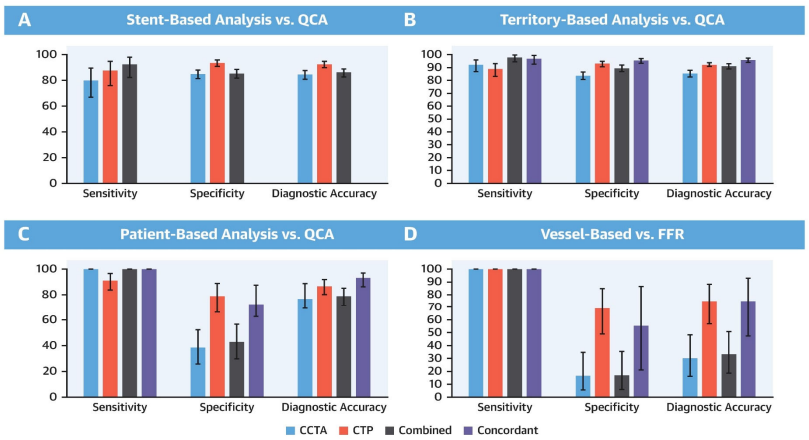
Dai T et al.. *European Radiology 2017*

36

CTP + CTA →↑ Diag rate /accuracy for ISR

150 pts

CENTRAL ILLUSTRATION: Diagnostic Accuracy of Coronary CTA, CTP, Combined and Concordant Coronary CTA + CTP Versus QCA and Invasive FFR



Andreini, D. et al. J Am Coll Cardiol Img. 2020;13(3):732-42.

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CTO

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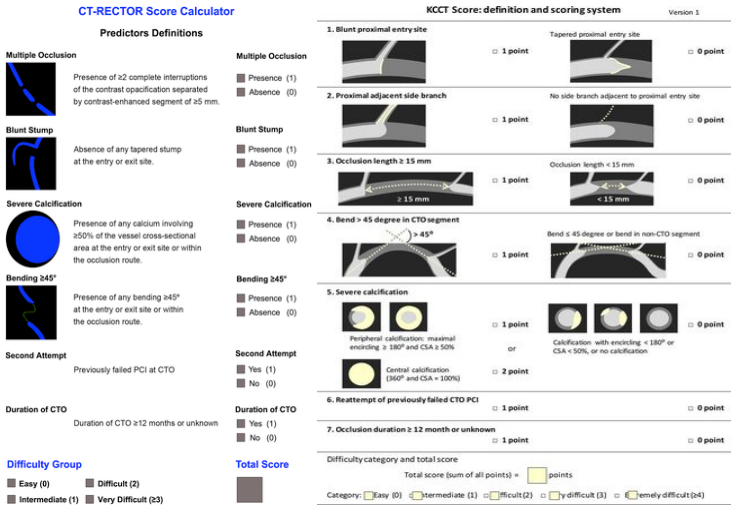
Planning CTO



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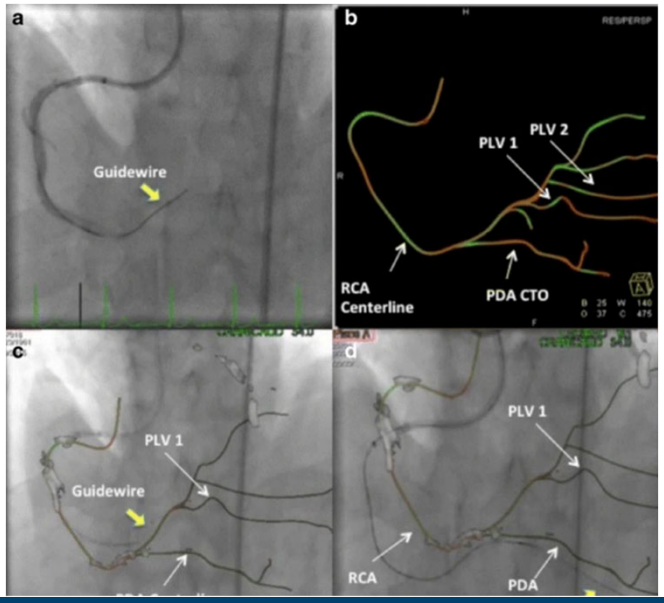
Opolski MP et al. *J Am Coll Cardiol Intv* 2015

Yu C-W et al. Circ: Cardiovasc Imag 2017.

39

Real time fusion (CTA+ICA)



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Ghoshhajra BB et al. Eur Radiol 2017

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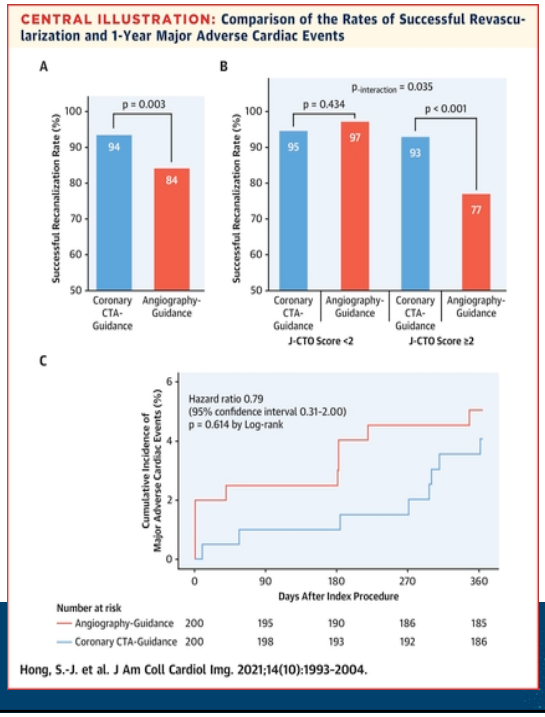
CTA→ ↑ success rate
↓ perforations, periproced MI



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MV-CAD

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cCTA for heart team decision in MV-CAD

223 patients	Heart team treatment recommendation based on coronary computed tomography angiography	
Heart team treatment recommendation based on conventional angiography	**CABG**	**PCI/equipoise CABG and PCI**
CABG	23.4% (52/222)	2.7% (6/222)
PCI/Equipoise CABG and PCI	4.5% (10/222)	69.4% (154/222)
Cohen's kappa 0.82 (95% CI 0.73–0.910)		

Agreement in 93% of the heart team's treatment recommendation.

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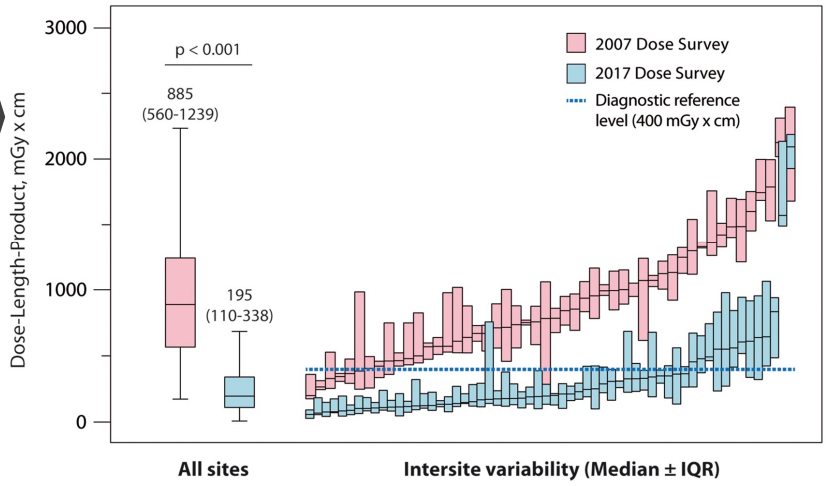
Collet C et al. EHJ 2018

43

78% ↓ in DLP 2017 vs 2007

61 hospitals from 32 countries (prospectively enrolled 4502 pts)



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Stocker TJ et al. *Eur Heart J* 2018

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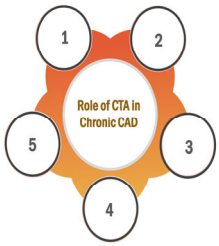
SCCT 2021 Expert Consensus Document on CTA



First line test for evaluating patients with:
- No known CAD and Stable Typical or Atypical Chest Pain, or Anginal Equivalent

Reasonable test for evaluating patients with:
- Known CAD and Stable Typical or Atypical Chest Pain, or Angina Equivalent

First line test for evaluating patients with:
- Coronary Anomalies
- Prior CABG, particularly if graft patency or location of LIMA is the primary objective

Reasonable test for evaluating patients with:
- A non-conclusive functional test; to obtain more precision regarding diagnosis and prognosis

Reasonable test for evaluating patients with:
- Coronary Stents > 3.0 mm
- Proximal, Non Bifurcation thin strut Stents < 3.0 mm
- Prior to Non Cardiac Surgery in younger patients with low-intermediate probability of CAD
- Evaluating Coronary Anatomy in patients with suspected Dissection of the Aorta

Minneapolis Heart Institute Foundation | GRAND ROUNDS

Narula J et al. Journal of Cardiovasc Comput Tomograph 2021

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Thank you!

Questions

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Back up Slides

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Limitations of CTA

- Obese patient's
- Extreme calcification
- Irregular heart rhythm (AF)

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SCCT 2021 Expert Consensus Document on CTA

Evaluation of Stable Coronary Artery Disease: Coronary CTA in Other Conditions

- It is appropriate to perform CTA for coronary artery evaluation prior to noncoronary cardiac surgery as an equivalent alternative to invasive angiography in selected patients, e.g., low-intermediate probability of CAD, younger patients with primarily non-degenerative valvular conditions.
- CTA may be considered an appropriate alternative to other noninvasive tests for evaluation of selected patients prior to noncardiac surgery.
- It is appropriate to perform CTA to exclude coronary artery disease in patients with suspected non-ischemic cardiomyopathy.
- It may be appropriate to perform late enhancement CT imaging to detect infiltrative heart disease or scar in selected patients who have non-ischemic or ischemic cardiomyopathy and who cannot undergo cardiac MRI. Such imaging may be performed if it has the potential to impact the diagnosis and/or treatment (e.g. planning for ablation therapy).
- It may be appropriate to perform CTA as an alternative to invasive coronary angiography for the screening of patients for coronary allograft vasculopathy in selected clinical practice settings.
- It is appropriate to perform CTA for the evaluation of coronary anomalies.

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Narula J et al. Journal of Cardiovasc Comput Tomograph 2021

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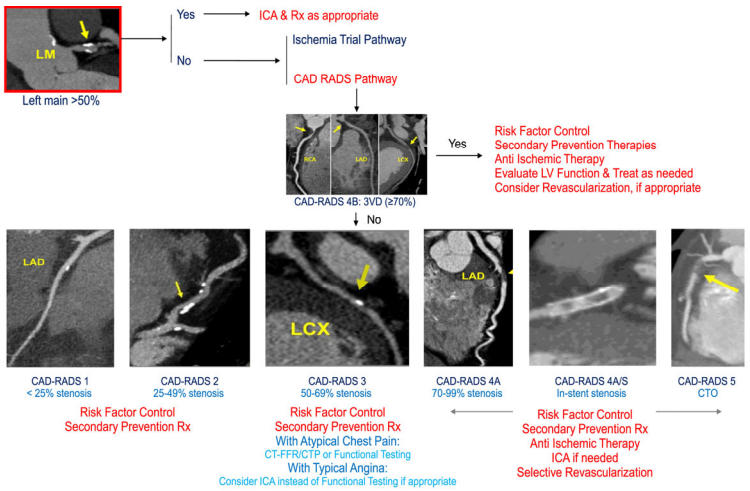
Decision making



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Narula J et al. Journal of Cardiovasc Comput Tomograph 2021

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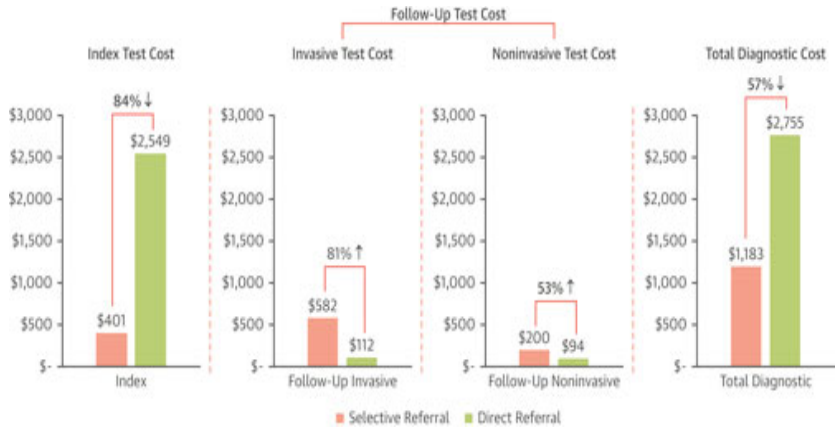
CONVERSE (cost)



Hyuk-Jae Chang et al. *J Am Coll Cardiol Img* 2018.

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CORE-64

Table 2 Diagnostic Accuracy of CTA for Detecting ≥50% Coronary Arterial Stenosis

	n	CAD	Sensitivity	Specificity	PPV	NPV	AUC
Quantitative CTA, all	371	63.1%	0.88 (0.83–0.92)	0.87 (0.80–0.92)	0.92 (0.88–0.95)	0.81 (0.74–0.87)	0.93 (0.90–0.95)
Quantitative CTA, <600	291	56.0%	0.85 (0.79–0.90)	0.90 (0.83–0.94)	0.91 (0.86–0.95)	0.83 (0.75–0.89)	0.93 (0.90–0.96)
Quantitative CTA, ≥600	80	88.8%	0.94 (0.86–0.98)	0.44 (0.14–0.79)	0.93 (0.85–0.98)	0.50 (0.16–0.84)	0.81 (0.71–0.89)
Quantitative CTA, without known CAD	273	55.7%	0.91 (0.85–0.95)	0.87 (0.79–0.92)	0.90 (0.84–0.94)	0.88 (0.81–0.93)	0.93 (0.90–0.96)
Visual CTA, all	371	63.1%	0.85 (0.80–0.89)	0.90 (0.83–0.94)	0.93 (0.89–0.96)	0.78 (0.73–0.87)	0.92 (0.89–0.95)
Visual CTA, calcium <600	291	56.0%	0.83 (0.76–0.88)	0.91 (0.85–0.96)	0.92 (0.87–0.96)	0.81 (0.71–0.85)	0.92 (0.89–0.95)
Visual CTA, calcium ≥600	80	88.8%	0.96 (0.88–0.99)	0.56 (0.21–0.86)	0.94 (0.86–0.98)	0.63 (0.24–0.91)	0.86 (0.77–0.93)
Quantitative CTA, intermed PTP	172	47.7%	0.89 (0.80–0.95)	0.88 (0.79–0.94)	0.87 (0.78–0.93)	0.90 (0.81–0.95)	0.93 (0.89–0.97)
Quantitative CTA, high PTP	98	70.4%	0.93 (0.84–0.98)	0.83 (0.64–0.94)	0.93 (0.84–0.98)	0.83 (0.64–0.94)	0.92 (0.85–0.96)
Quantitative CTA, known CAD	98	83.7%	0.83 (0.73–0.90)	0.88 (0.62–0.98)	0.97 (0.90–1.00)	0.50 (0.31–0.69)	0.93 (0.86–0.97)

Arbab-Zadeh A et. JACC 2012

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CORE-64

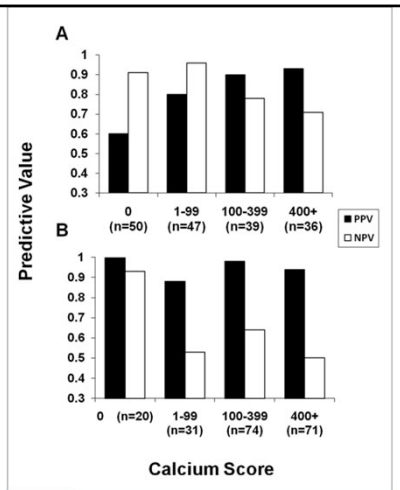

Figure 2 Predictive Values According to Pre-Test Probability and Presence/Extent of Coronary Calcification

Shown is a plot of positive predictive values **(solid bars)** and negative predictive values **(open bars)** for **(A)** patients with intermediate pre-test probability of coronary artery disease (n = 172), and **(B)** patients with either high pre-test probability or known coronary artery disease (n = 196 combined), grouped into patients without calcification (calcium score 0) and with mild calcification (score 1 to 99), moderate calcification (score 100 to 399), and severe coronary calcification (score >400).

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Arbab-Zadeh A et. JACC 2012

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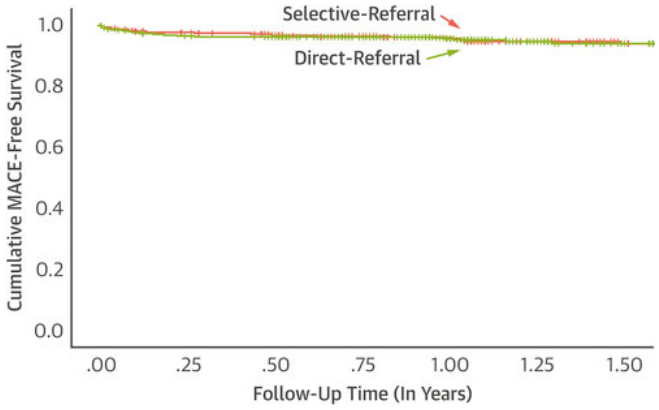
CONSERVE



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Hyuk-Jae Chang et al. *J Am Coll Cardiol Img* 2018

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Contrast

- Intravenous contrast doses are typically less than 75 mL in most labs, a value associated with very low (<1 percent) rates of contrast-induced nephropathy or adverse outcomes

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CONSERVE

Table 1.
Downstream Procedural Use Following Randomization

	Selective Referral (n = 784 Underwent Index CCTA)		Direct Referral (n = 719 Underwent Index ICA)		p Value
	Total	%	Total	%	
Invasive procedures					
Invasive coronary angiography	179	23	30	4	<0.001
Fractional flow reserve	0	0	41	6	<0.001
Percutaneous coronary intervention	89	11	109	15	<0.001
Coronary artery bypass surgery	9	1	18	3	0.075
Revascularization	98	13	127	18	0.007

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CT-FFR limitation

- lower in patients with CT-FFR values between 0.70 and 0.80 (so called "gray zone")
- Not validated for the assessment of left main coronary artery stenosis or for patients with three-vessel CAD, particularly when involving total occlusions in the coronary vascular tree

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