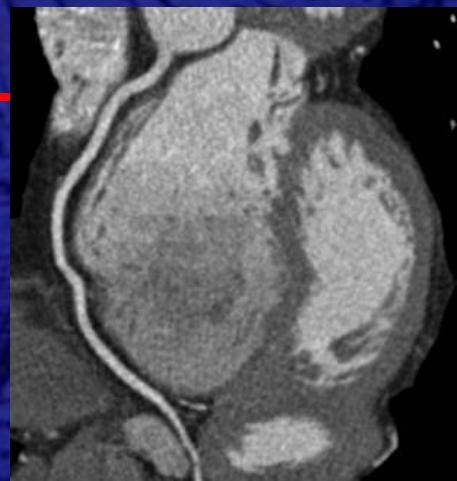
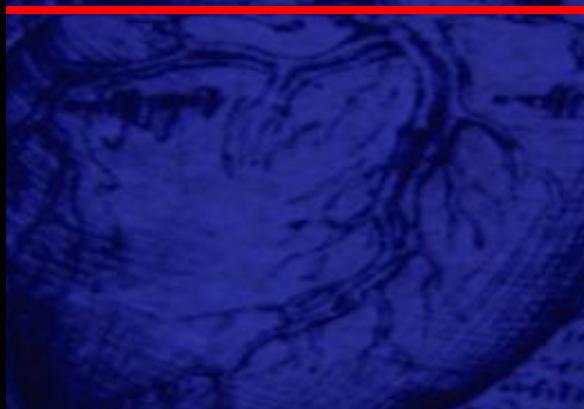
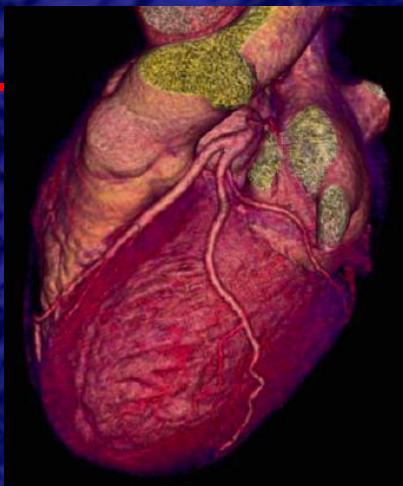


Multislice Computed tomography and CAD



Jacques Boschat et
Martine Gilard
Brest France

MSCT and Coronary artery disease

Conventional coronary angiography:

- Gold standard for evaluation of coronary artery lesions
- Invasive investigation: complications
- About 20% à 35% of diagnostic coronary angiography are normal (Twice more in women)
- All coronary angiograms are not followed by PCI (371 000 vs 189 000 PCI (2018))



Indication for non-invasive investigations

MSCT and Coronary artery

Will MSCT be used as a replacement
for conventional coronary angiography?

MSCT and Coronary artery

Image quality: MSCT and Coronary angiography

	Cath Lab	16 MCST	64 MCST	320MCST
Radiation exposure	3-5mSv	6-12mSv	13-18mSv	
Spatial resolution	200 μm	750 μm	350 μm	290 μm
Temporal resolution	100 ms	210 ms	175 ms	27ms
Flow	+	0	0	0

MSCT and Coronary artery disease

Current Indications

Patients with unknown CAD

- Cardiomyopathy evaluation
- Pre operative assessment of CAD
 - Non cardiac
 - valvular surgery
- Detection of CAD in patients with a low or intermediate prevalence of CAD

Patients with known CAD

- CTO
- Follow-up
 - graft patency
 - post stent

MSCT and Coronary artery

Current Indications

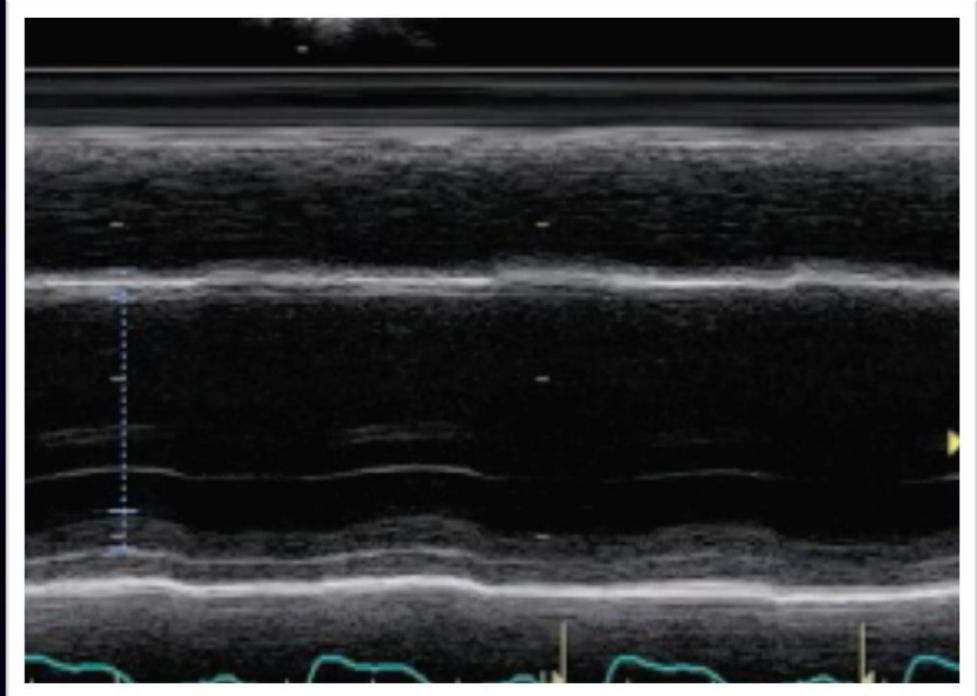
Patients with unknown CAD

- Cardiomyopathy evaluation
- Pre operative assessment of CAD
 - Non cardiac
 - valvular surgery
- Detection of CAD in patients with a low or intermediate prevalence of CAD

MSCT and Coronary artery

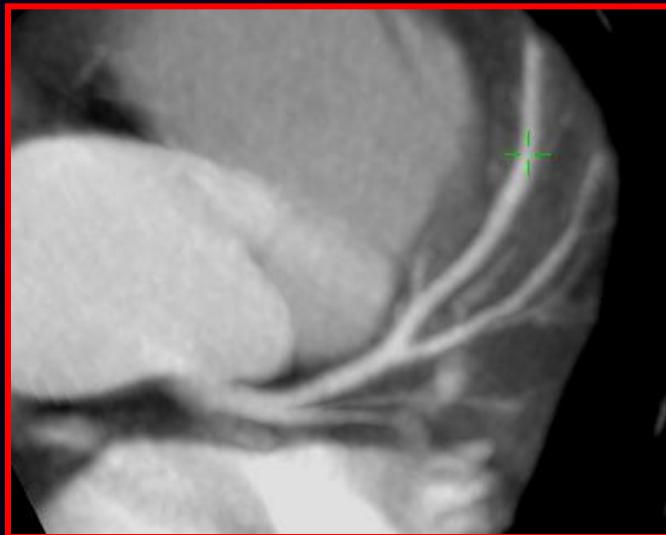
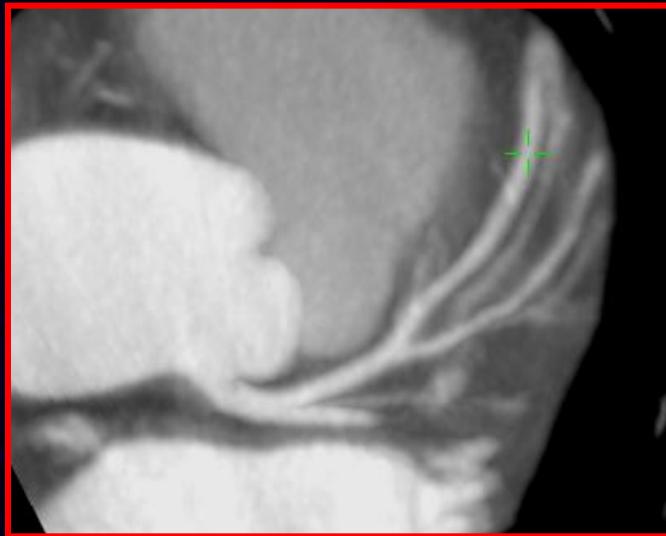
MSCT and Cardiomyopathy

- Patient history:
 - 70 yr-old male
 - Current smoker and hypertension
 - Echocardiography:
 - EF: 28%
 - Global hypokinesia

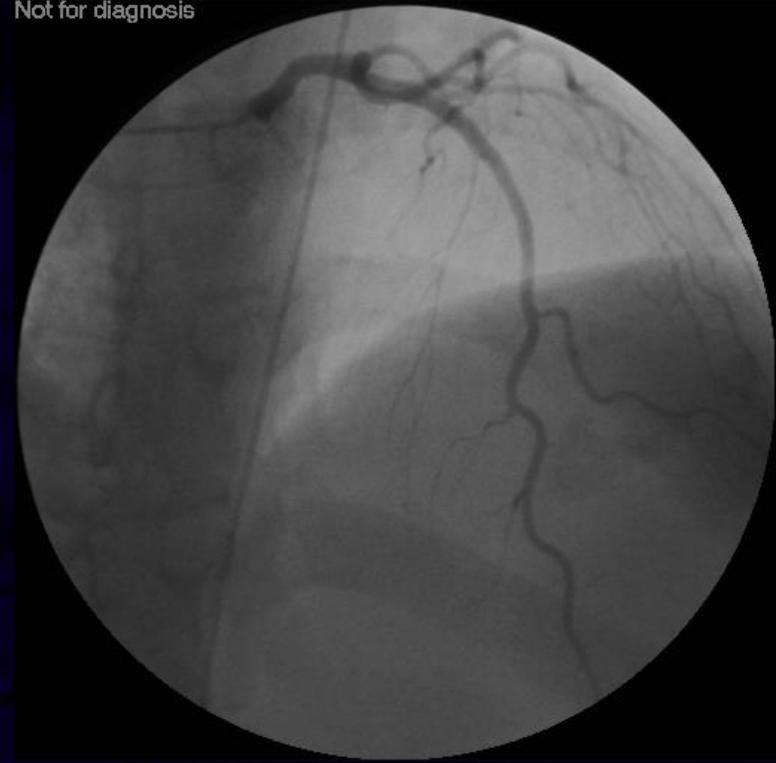


MSCT and Coronary artery

MSCT and Cardiomyopathy

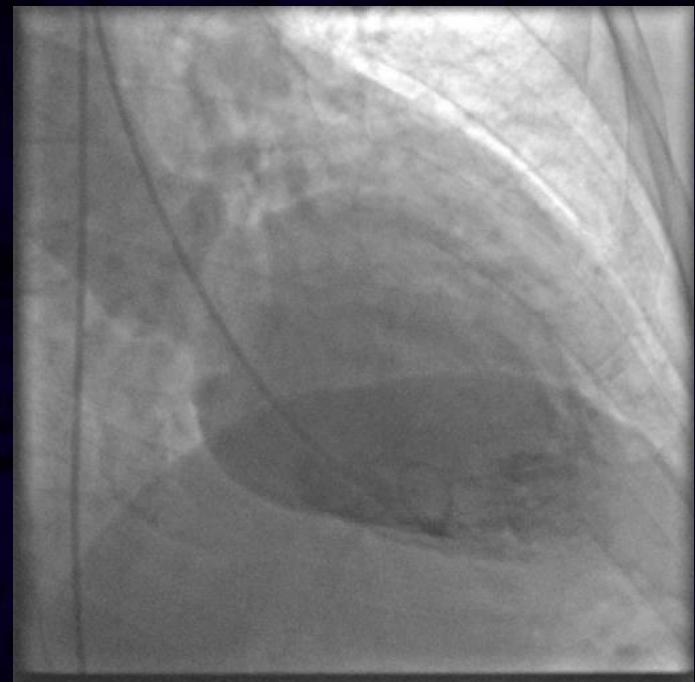
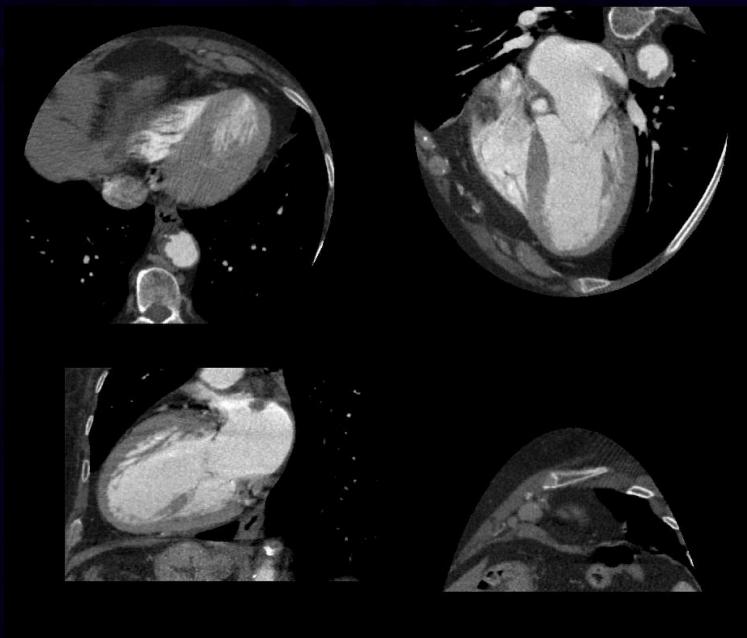
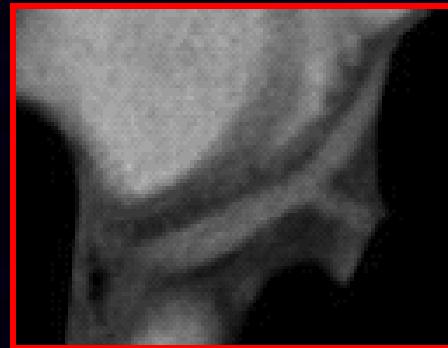


Not for diagnosis



MSCT and Coronary artery

MSCT and Cardiomyopathy



MSCT and Coronary artery

MSCT and Cardiomyopathy

Accuracy of 16-detector Multislice Spiral Computed Tomography
in the initial evaluation of dilated cardiomyopathy

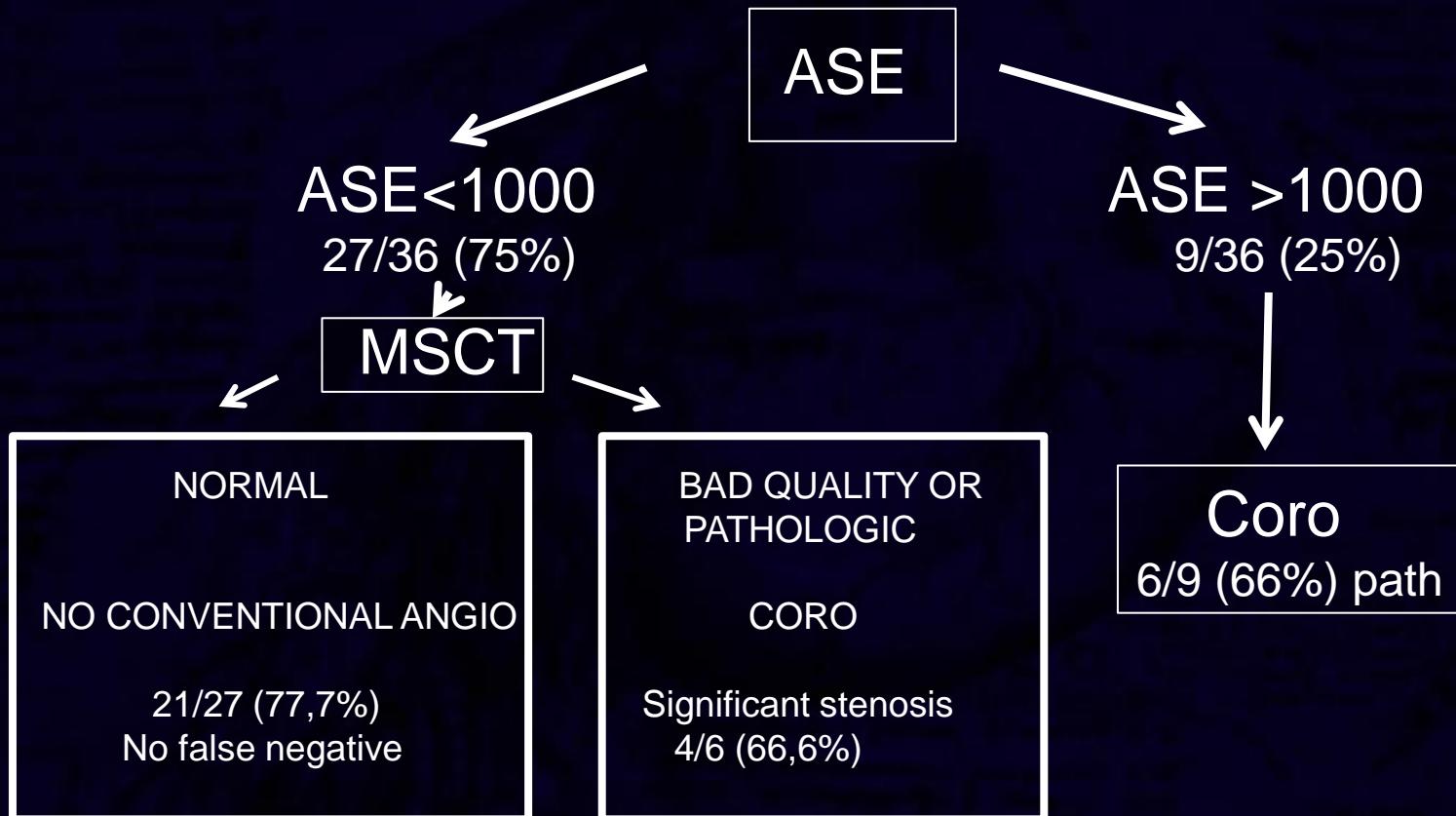
Jean-Christophe Cornily ^{a,*}, Martine Gilard ^a, Grégoire Le Gal ^b, Pierre-Yves Pennec ^a,
Ulric Vinsonneau ^c, Jean-Jacques Blanc ^a, Jacques Mansourati ^a, Jacques Boschat ^a

Eur J Radiol 2007; 61:84-90

- 36 DCM patients underwent
 - MSCT
 - Conventional coronary angiography
- MSCT assess:
 - Calcium Scoring
 - The number of coronary stenosis > 50%
 - Ventricular volume and LV function
 - The venous network

MSCT and Coronary artery

MSCT and Cardiomyopathy



MSCT and Coronary artery

MSCT and Cardiomyopathy

- Results

- Coronary

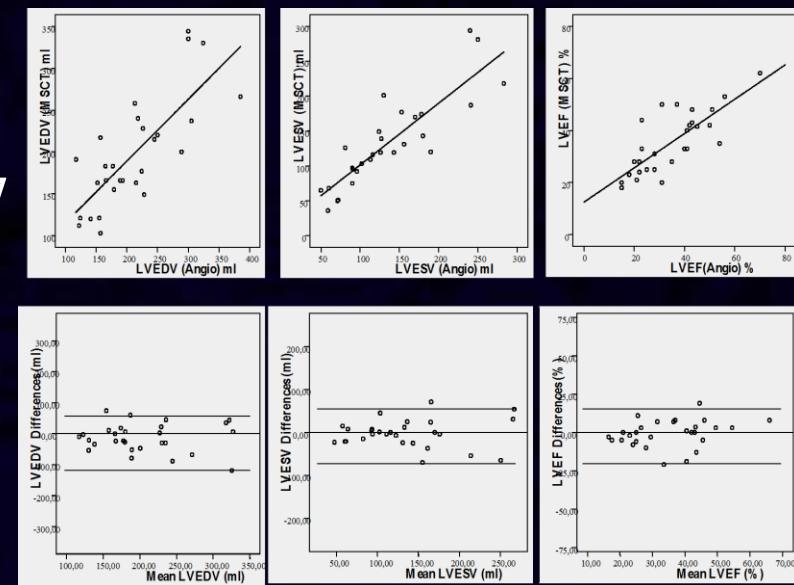
- Interpretable in 30 pts (91%)
 - 10/11 pts with stenosis ($K=0.93$) (msct/ica)

- Ventricular function

- Analysable in 28 pts (85%)
 - Telediastolic volume $r = 0.77$
 - Telesystolic volume $r = 0.87$
 - Ejection fraction $r = 0.78$

- Lateral veins

- 100%



MSCT and Coronary artery

MSCT and Cardiomyopathy

	Paper	Year	Nb	Sensi	Speci	PPV	NPV
Ghostine	JACC	2006	66	97%	95%	93%	97%
Andreini	JACC	2007	61	99%	96%	81%	99%
Ghostine	EHJ	2008	93	98%	92%	91%	98%
Polain De Warux	EHJ	2008	71	100%	95%	94%	100%
Andreini	Circ Cardiovasc Imag	2009	132	100%	98%	98%	100%
Boulmier	AMC	2009	59	87%	98%	67%	99%
Bhatti	J Nucl Cardiol	2011	452	98%	97%	94%	99%

MSCT and Coronary artery

Current Indications

Patients with unknown CAD

- Cardiomyopathy evaluation
- Pre operative assessment of CAD
 - Non cardiac
 - valvular surgery
- Detection of CAD in patients with a low or intermediate prevalence of CAD

MSCT and Coronary artery

Pre operative assessment in valvular surgery

- 40 yr-old male
 - Echocardiography:
 - Annuloaortic ectasia
 - Aortic regurgitation
 - Preparation of aortic replacement

MSCT and Coronary artery

Pre operative assessment in valvular surgery

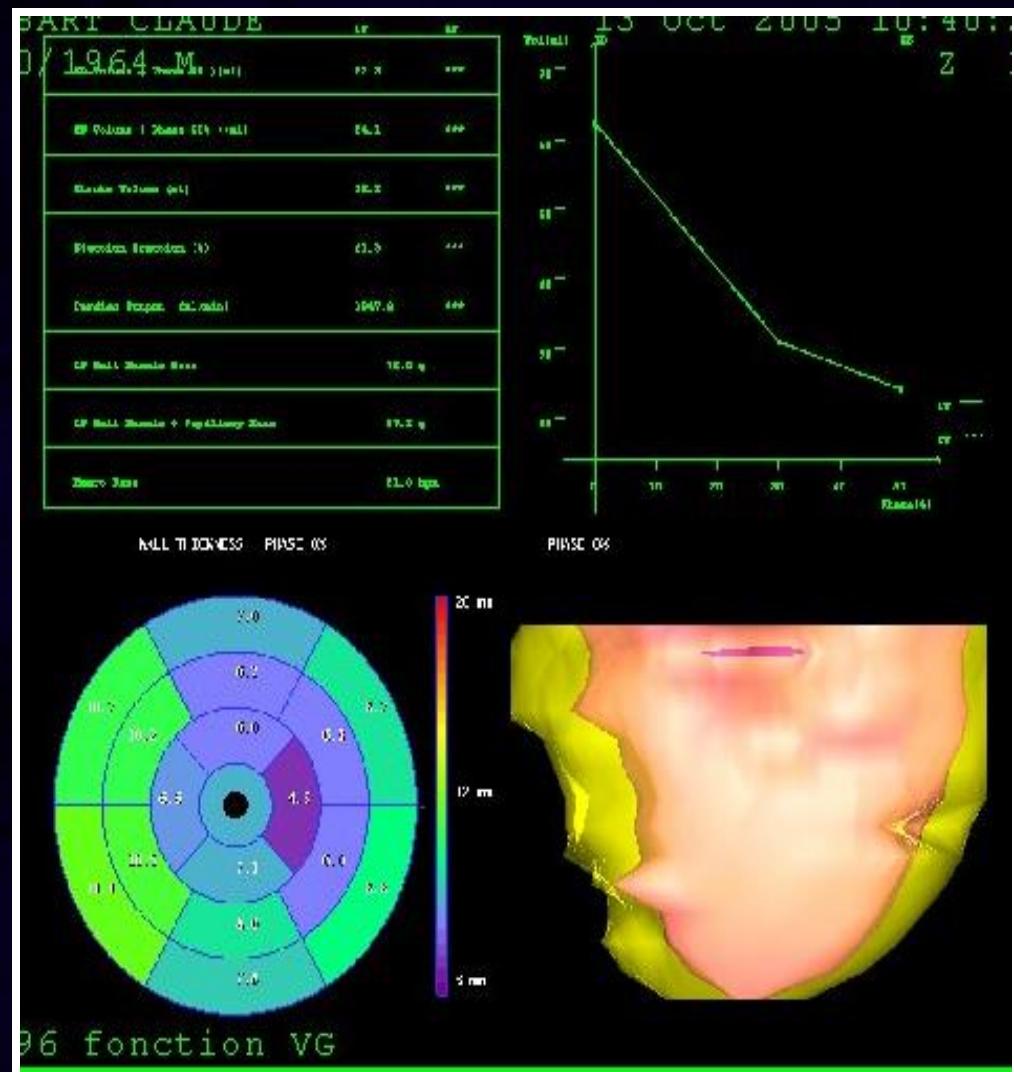
Diagnostics

Processus extension

Coronary analysis

Aortic valve analysis

Ventricular Function



MSCT and Coronary artery

Accuracy of Multislice Computed Tomography in the Preoperative Assessment of Coronary Disease in Patients With Aortic Valve Stenosis

Martine Gilard MD, , , Jean-Christophe Cornily MD, Pierre-Yves Pennec MD, Cedric Joret, Grégoire Le Gal MD†, Jacques Mansourati MD, Jean-Jacques Blanc MD and Jacques Boschat M
JAm Coll Cardiol. 2006;47:2020-4

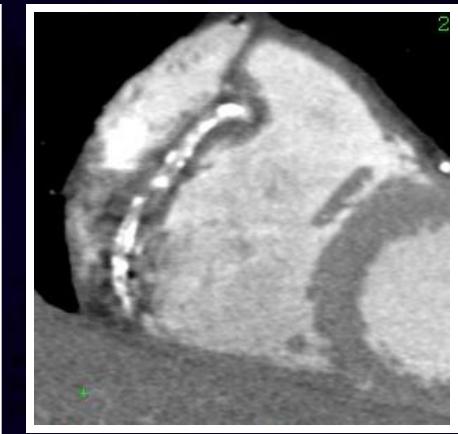
- 55 consecutive pts
 - Mean transvalvular pressure gradient: 57 ± 16 mmHg
 - Aortic valve area: 0.35 ± 0.06 cm 2 /m 2
- MSCT and conventional angiography
- Calcium scoring: a cut-off of 1000 was chosen as the best compromise between:
 - Proportion of non-interpretable MSCTs
 - Pts in whom the MSCT alone rule out CAD

MSCT and Coronary artery

Pre operative assessment of CAD in valvular surgery

- Detection of CAD:

- Se: 100%
- Sp: 80%
- PPV: 55%
- NPV: 100%



- Image quality

- Good: 41 pts (75%)

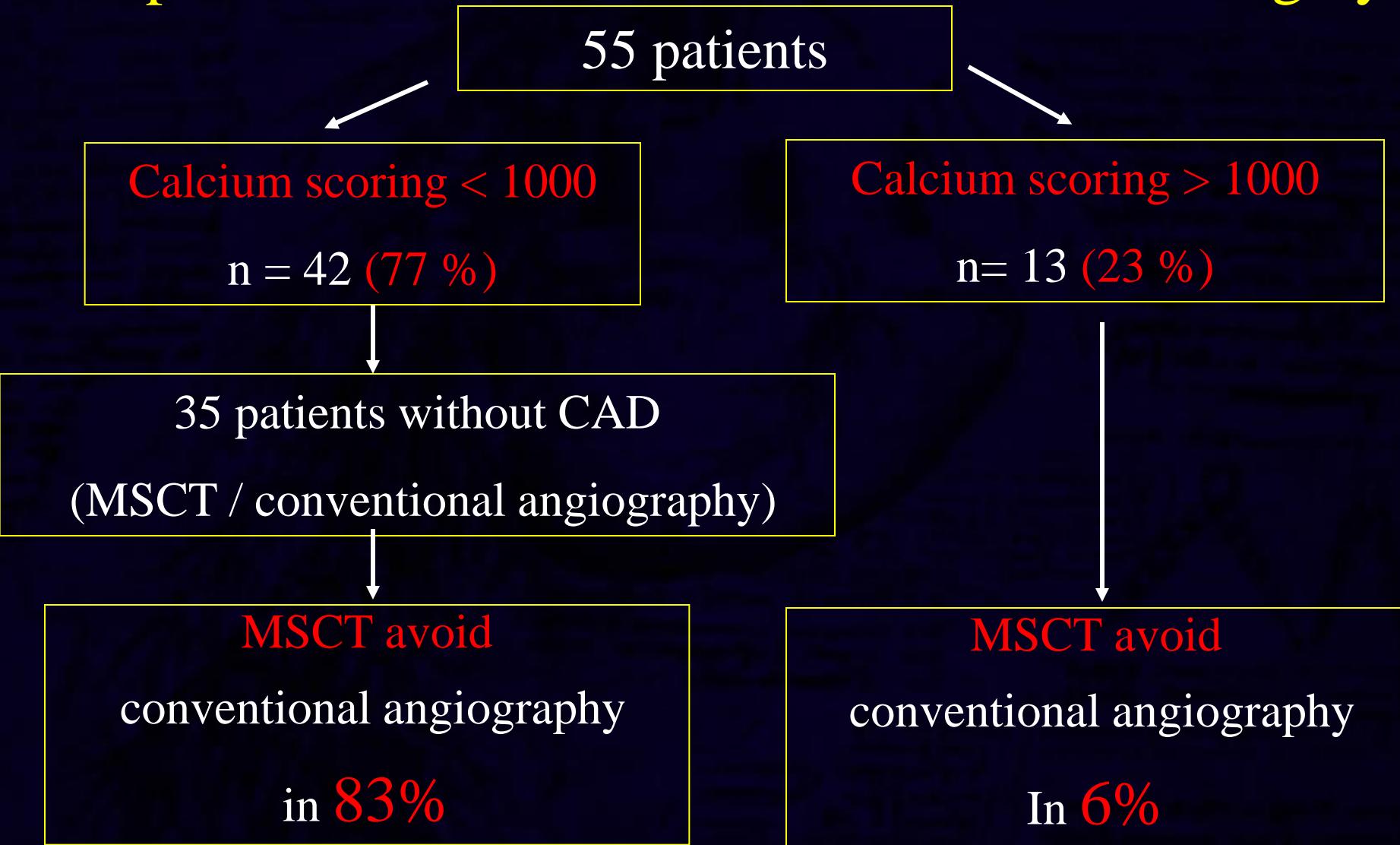
- Moderate: 10pts (18%)

- Bad: 4 pts (7%)

11/14 (80%) = calcifications ++

MSCT and Coronary artery

Pre operative assessment of CAD in valvular surgery



MSCT and Coronary artery

Pre operative assessment of CAD in valvular surgery Indication of MSCT

	Paper	Year	Nb	Sensi	Speci	PPV	NPV
Laissy	Heart	2007	40	85%	93%	85%	93%
Meijboom	JACC	2006	66	97%	95%	93%	97%
Reant	AJC	2006	40	77%	98%	43%	99%
Holmstrom	IJCI	2006	23	63%	96%	52%	98%
Mowat	Heart	2008	1286	99%	89%	93%	100%
Bettencourt	CCI	2009	237	95%	89%	66%	99%
Jakamy	AMC	2012	48	77%	89%	71%	91%
Larsen	IJC	2013	181	68%	91%	81%	83%
Oposki	JACC imag	2016	1107	93%	89%	92%	99%

MSCT and Coronary artery

Pre operative assessment of CAD in valvular surgery Indication of MSCT

- Aortic valve stenosis
- Aortic valve regurgitation
- Mitral valve regurgitation
- Mitral valve stenosis:
 - atrial fibrillation

MSCT and Coronary artery

Current Indications

Patients with unknown CAD

- Cardiomyopathy evaluation
- Pre operative assessment of CAD
 - Non cardiac
 - valvular surgery
- Detection of CAD in patients with a low or intermediate prevalence of CAD

MSCT and Coronary artery

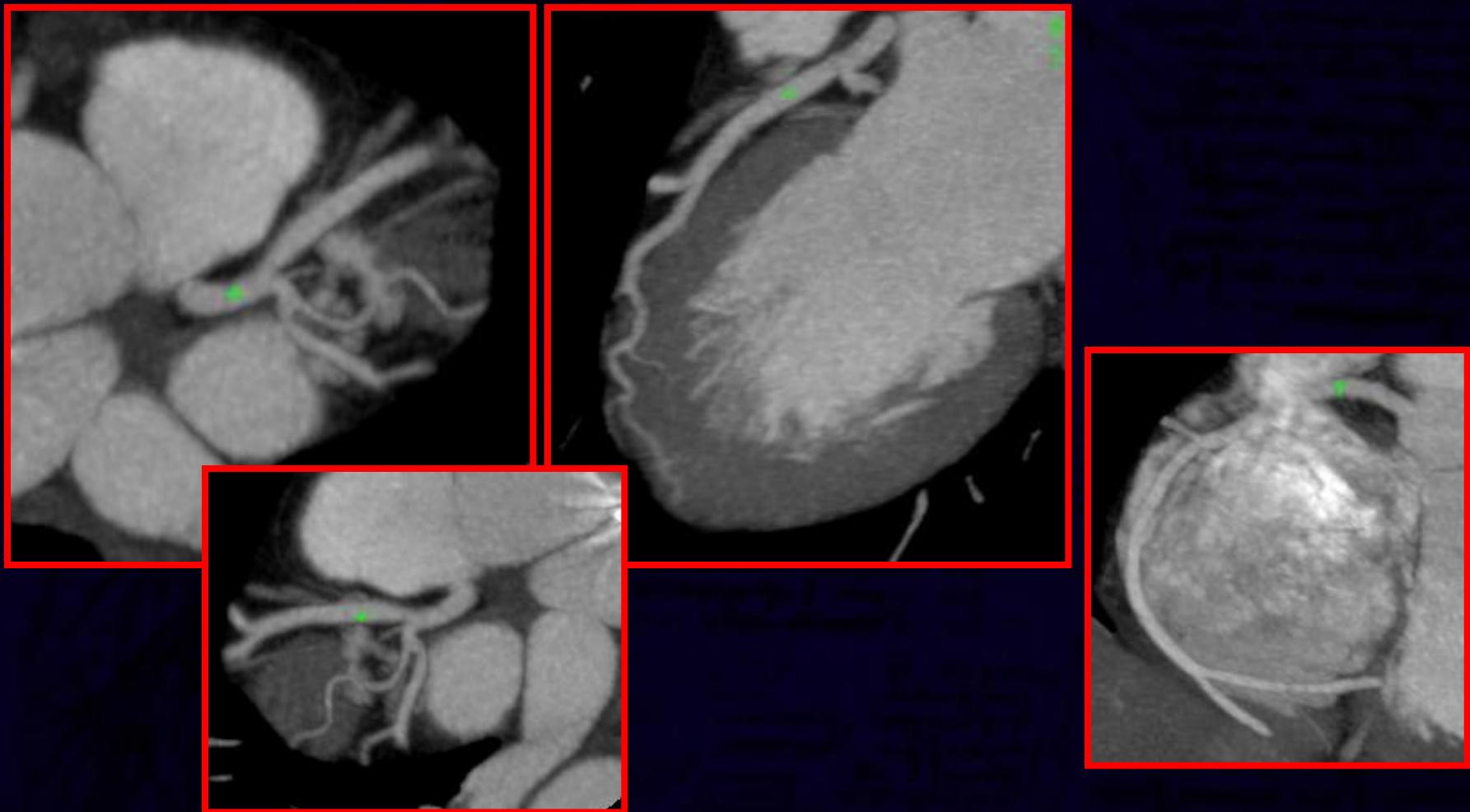
Detection of CAD

Patients with a low or intermediate prevalence of CAD

- 44 yr-old female
 - Current smoker
 - October 2004: one chest pain
 - Normal electrocardiogram
 - Exercise test: positive (180 W)

MSCT and Coronary artery

Detection of CAD
patients with a low or intermediate prevalence of CAD



MSCT and Coronary artery

- A lot of publications
- Limitations of the selection
- Small number of patients < 110
- Single-center study design



MSCT and Coronary artery

MSCT versus Angiography

Auteurs	Revue	Année	N	Se	Sp	PPV	NPV	NA
4 Nieman	Lancet	2001	35	95%	86%	81%	97%	30%
Achenbach	Circ	2001	64	91%	84%	59%	98%	32%
16 Nieman	Circ	2002	58	95%	86%	80%	97%	0%
Gillard M	AJC	2005	27	100%	93%	100%	92%	7%
Mollet	JACC	2005	51	95%	98%	87%	99%	0%
Leshka	EHJ	2005	67	94%	97%	87%	99%	0%
64 Raff	JACC	2005	70	91%	92%	80%	97%	1%
Pugliese	ER	2006	35	100%	90%	96%	100%	0%
Ehara	Circ J	2006	67	98%	86%	98%	86%	8%
Ropers	AJC	2006	84	96%	91%	83%	98%	4%
Meijboom	Heart	2007	104	100%	75%	96%	100%	0%
128 Moldi	Radiologe	2010	20	88%	92%	92%	100%	0%
Alkadhi	Heart	2010	61	93%	94%	89%	97%	8%
256 Zhao	EHJ	2010	52	94%	87%	83%	96%	6%
Dewey	Circ	2010	30	100%	94%	92%	100%	0%
320 DeGraaf	EHJ	2010	42	100%	81%	88%	100%	6%

MSCT and Coronary artery

MSCT versus Angiography

Multicenter Studies

Author	Center	Paper	Year	N	Se	Sp	PPV	NPV	NA
Budoff	16	JACC	2008	230	94%	83%	48%	99%	1.3%
Miller	9	NEJM	2008	291	85%	90%	91%	83%	0.5%

MSCT and Coronary artery

Detection of CAD

MSCT has moderate diagnostic value for the detection of significant obstructive coronary artery stenosis **in a population with a high prevalence of CAD.**

Hoffman et al Circulation 2004;110:2638-43

Meijboom WB et al J Am Coll Cardiol 2007;15:1469-1475

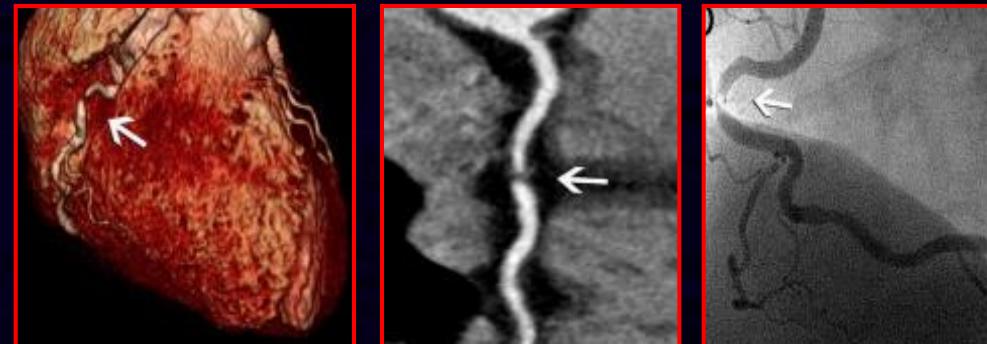
MSCT and Coronary artery

64-Slice Computed Tomography Coronary Angiography in Patients With High, Intermediate, or Low Pretest Probability of Significant Coronary Artery Disease

W. Bob Meijboom MD, †, Carlos A.G. van Mieghem MD, †, Nico R. Mollet MD, PhD, †, Francesca Pugliese MD, †, Annick C. Weustink MD, †, Niels van Pelt MD, †, Filippo Cademartiri MD, PhD†, Koen Nieman MD, PhD, Eric Boersma MSc, PhD, Peter de Jaegere MD, PhD, Gabriel P. Krestin MD, PhD† and Pim J. de Feyter MD, PhD, FAC

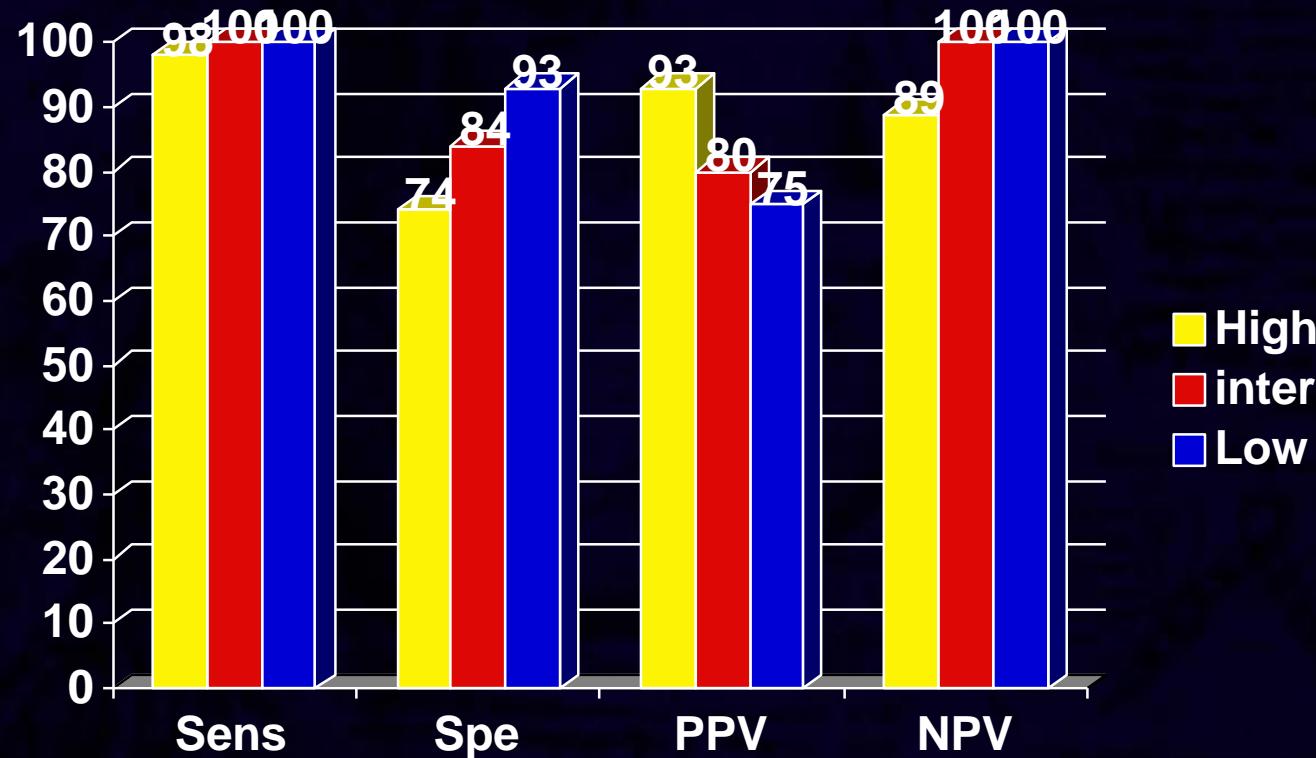
J Am Coll Cardiol 2007;15:1469-1475

- 254 patients, during a 24 month period
- Estimated pretest probability for obstructive CAD
(Chest discomfort, traditional RF, age, gender)
 - High probability: 105
 - Intermediate probability: 83
 - Low probability: 66



MSCT and Coronary artery

Detection of CAD
patients with a low or intermediate prevalence of CAD



MSCT does not provide additional relevant diagnostic information in symptomatic patients with a high pretest probability of CAD

Indications for diagnostic testing in patients with suspected CAD and stable symptoms

	Asymptomatic ^a		Symptomatic						Ref ^e	
			Probability of significant disease ^b							
			Low (<15%)		Intermediate (15–85%)		High (>85%)			
	Class ^c	Level ^d	Class ^c	Level ^d	Class ^c	Level ^d	Class ^c	Level ^d		
Anatomical detection of CAD										
Invasive angiography	III	A	III	A	IIb	A	I	A	50–52,54	
CT angiography ^{f,g}	III	B	III	C	IIa	A	III	B	57–62	
Functional test										
Stress echo	III	A	III	A	I	A	III	A	63–65	
Nuclear imaging	III	A	III	A	I	A	III	A	60,66–70	
Stress MRI	III	B	III	C	I	A	III	B	71–75	
PET perfusion	III	B	III	C	I	A	III	B	67,69,70,76,77	
Combined or hybrid imaging test										
	III	C	III	C	IIa	B	III	B	78–83	

MSCT and Emergency

MSCT Limitations

Negative predictive value

- Multicenter study (9 centers)
 - 400 pts consented
 - 291 pts with calcium score ≤ 600 (22 % pts excluded)
 - Disease prevalence 56%
 - Comparison MSCT and conventional coronary angiography

MSCT and Emergency

MSCT Limitations

Negative predictive value

- Sensitivity: 85%
- Specificity: 90%
- Positive predictive value: 91%
- Negative predictive value: 83%

Multidetector CT angiography accurately identifies the presence and severity of obstructive coronary artery disease and subsequent revascularization in symptomatic patients.

« The negative and positive predictive values indicate that multidetector CT angiography cannot replace conventional coronary angiography at present. »

MSCT and Coronary artery

Midterm Prognosis of Patients With Suspected Coronary Artery Disease and Normal Multislice Computed Tomographic Findings

A Prospective Management Outcome Study

Martine Gilard, MD; Grégoire Le Gal, MD; Jean-Christophe Cornily, MD; Ulrich Vinsonneau, MD; Cédric Joret, MD; Pierre-Yves Pennec, MD; Jacques Mansourati, MD; Jacques Boschat, MD

Arch Intern Med 2007;165:1686-89

Total number of patients	141
Male (%)	88 (63%)
Weight (kg)	76 +/- 16.8
Creatinine clearance (ml/min)	78.5 +/- 14.8
Age (years)	59 +/- 12
Smokers (%)	42.5
Dyslipidemia (%)	51.5
Diabetes mellitus (%)	13.5
Hypertension (%)	50
Family history (%)	20
Beta-blocker (%) before MSCT	52
Intra-venous Beta-blocker (%)	15

Mean follow up:

- 14,7 months (range 6 to 26)
- No patient lost
- No patient died during follow-up

In this first pragmatic management outcome study:

- Mean follow-up of 14,7 months
- 137 of 141 pts (97,2%) : clinically event free
- This value can be compared with PNV

MSCT and Coronary artery

Current Indications

Patients with known CAD

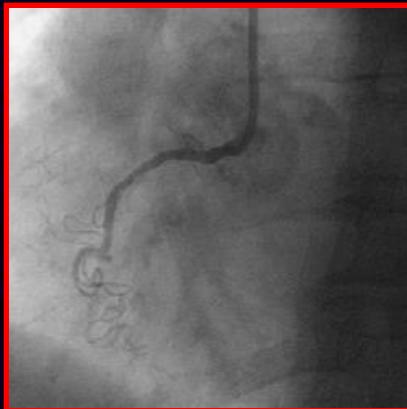
- CTO
- Follow-up
 - graft patency
 - post stent

MSCT and Coronary artery

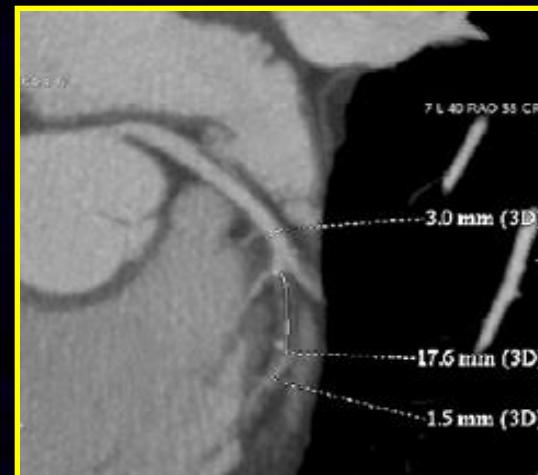
Chronic total occlusion and MSCT

45 patients referred for PCI of CTO

Multivariate analysis identified as an independent predictors of procedural failure:



Severe calcification



Occlusion length > 15 mm

MSCT and Coronary artery

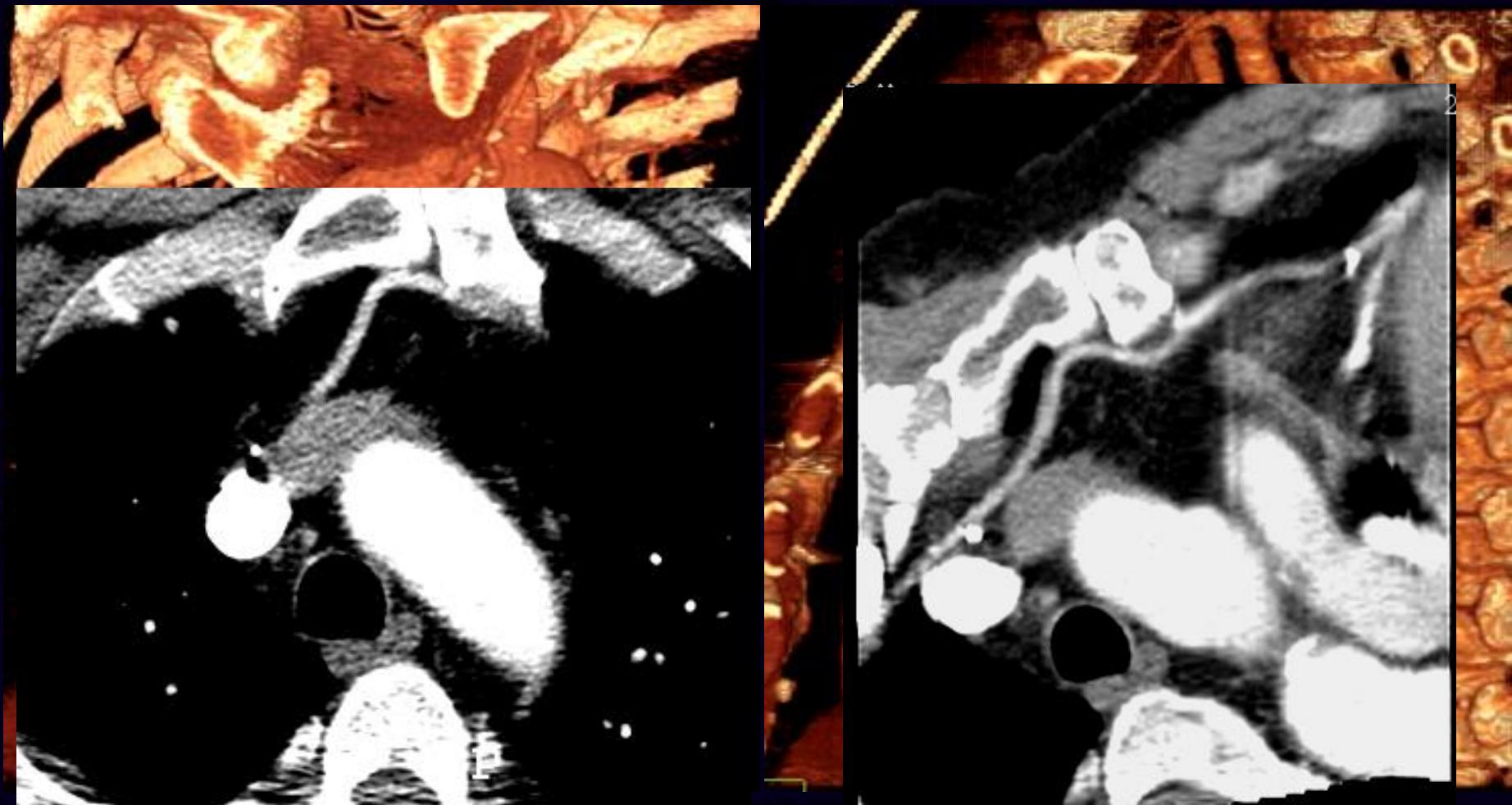
Current Indications

Patients with known CAD

- CTO
- Follow-up
 - graft patency
 - post stent

MSCT and Coronary artery

IMA Graft



MSCT and Coronary artery

Arterial Graft

Arterial T-Graft in Coronary Surgery: Comparison of Selective Coronary Angiography and Multi-Slice Computed Tomography

S. Eifert¹, M. Oberhoffer¹, B. Wintersperger¹, B. Reichart¹, P. Boekstegers¹, C. Vicol¹

Thorac Cardiovasc Surg. 2007;55:173-6

- 26 patients
- 59 pontages mammaire en Y
- 130 anastomoses distales soit 3,5 anastomose par patient

Sensibilité	Spécificité	VPP	VPN
98,9%	50,8%	94,6%	99,9%

Coronarographie conventionnelle est préférable dans les cas complexes

MSCT and Coronary artery

Current Indications

Patients with known CAD

- CTO
- Follow-up
 - graft patency
 - post stent

MSCT and Coronary artery

MSCT and Coronary artery

Perspective

- Non invasive assessment of atherosclerotic plaque in the vessel wall:

- Detection lipid and calcium
 - Good correlation to IVUS* and Histology**
 - Problem with the spatial resolution
 - 290 µm MSCT vs 80 µm IVUS vs 10µm OCT



**Schroeder S et al JACC 2001*

***Fayad Z et al Circulation 2002*

- However the evolution of vulnerable plaque are not predictive and we are not able to identify the single lesion that may rupture and cause ACS

MSCT and Coronary artery

Limits of MSCT in 2019

- Average Time of analysis: 10 mn
- Radiation exposure
- High heart rates, arrhythmias :
- Accuracy of Coronary stenoses
 - Small vessels
 - Severely calcified vessels
 - Collateral circulation
- Coronary spasm
- Intra-stent restenosis in small diameter stents

MSCT and Coronary artery

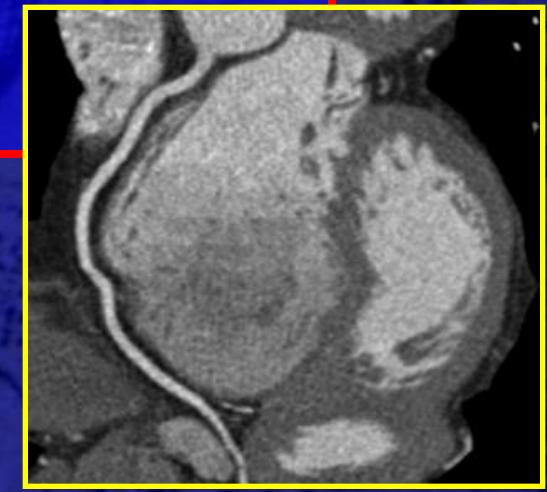
Conclusion

La précision de MSCT pour la détection des sténoses coronaires est intéressante, mais la Sensibilité n'est toujours pas assez élevé pour les besoins diagnostiques courants.

La forte VPN d'un MSCT normal est utile pour éliminer une coronaropathie

La possibilité de coupes transversales des coronaires en tant qu'outil potentiel de stratification du risque peut permettre une evaluation non invasive de la paroi,mais doit être davantage approfondie avant d'être utilisé en pratique

Guide de bonnes pratiques et recommandations en imagerie en coupe: Le scanner cardiaque



*J Radiol 2009 Sep;90
Arch Cardiovasc Dis 2009;suppl 1: 13-22*

2013 ESC guidelines on the management of stable coronary artery disease

www.escardio.org/guidelines

European Heart Journal 2013 - doi:10.1093/eurheartj/eht296



Use of coronary CTA for the diagnosis of SCAD

Recommendations	Class	Level
Coronary CTA should be considered as an alternative to stress imaging techniques for ruling out SCAD in patients within the lower range of intermediate PTP for SCAD in whom good image quality can be expected.	IIa	C
Coronary CTA should be considered in patients within the lower range of intermediate PTP for SCAD after a non-conclusive exercise ECG or stress imaging test or who have contraindications to stress testing in order to avoid otherwise necessary invasive coronary angiography if fully diagnostic image quality of coronary CTA can be expected.	IIa	C
Coronary calcium detection by CT is not recommended to identify individuals with coronary artery stenosis.	III	C
Coronary CTA is not recommended in patients with prior coronary revascularization.	III	C
Coronary CTA is not recommended as a 'screening' test in asymptomatic individuals without clinical suspicion of coronary artery disease.	III	C

CT = computed tomography; CTA = computed tomography angiography; ECG = electrocardiogram; PTP = pre-test probability; SCAD = stable coronary artery disease.

This slide corresponds to Table 16 in the full text.

Imaging in patients with suspected NSTE-ACS

Recommendations	Class	Level
In patients with no recurrence of chest pain, normal ECG findings and normal levels of cardiac troponin (preferably high-sensitivity), but suspected ACS, a non-invasive stress test (preferably with imaging) for inducible ischaemia is recommended before deciding on an invasive strategy.	I	A
Echocardiography is recommended to evaluate regional and global LV function and to rule in or rule out differential diagnoses.	I	C
MDCT coronary angiography should be considered as an alternative to invasive angiography to exclude ACS when there is a low to intermediate likelihood of CAD and when cardiac troponin and/or ECG are inconclusive.	IIa	A

ACS = acute coronary syndromes; CAD = coronary artery disease; ECG = electrocardiogram; LV = left ventricular; MDCT = multidetector computed tomography.