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Pre-Operative Risk Assessment with Nuclear Imaging and Cardiac CT

Paolo Raggi, MD, FACC, FAHA

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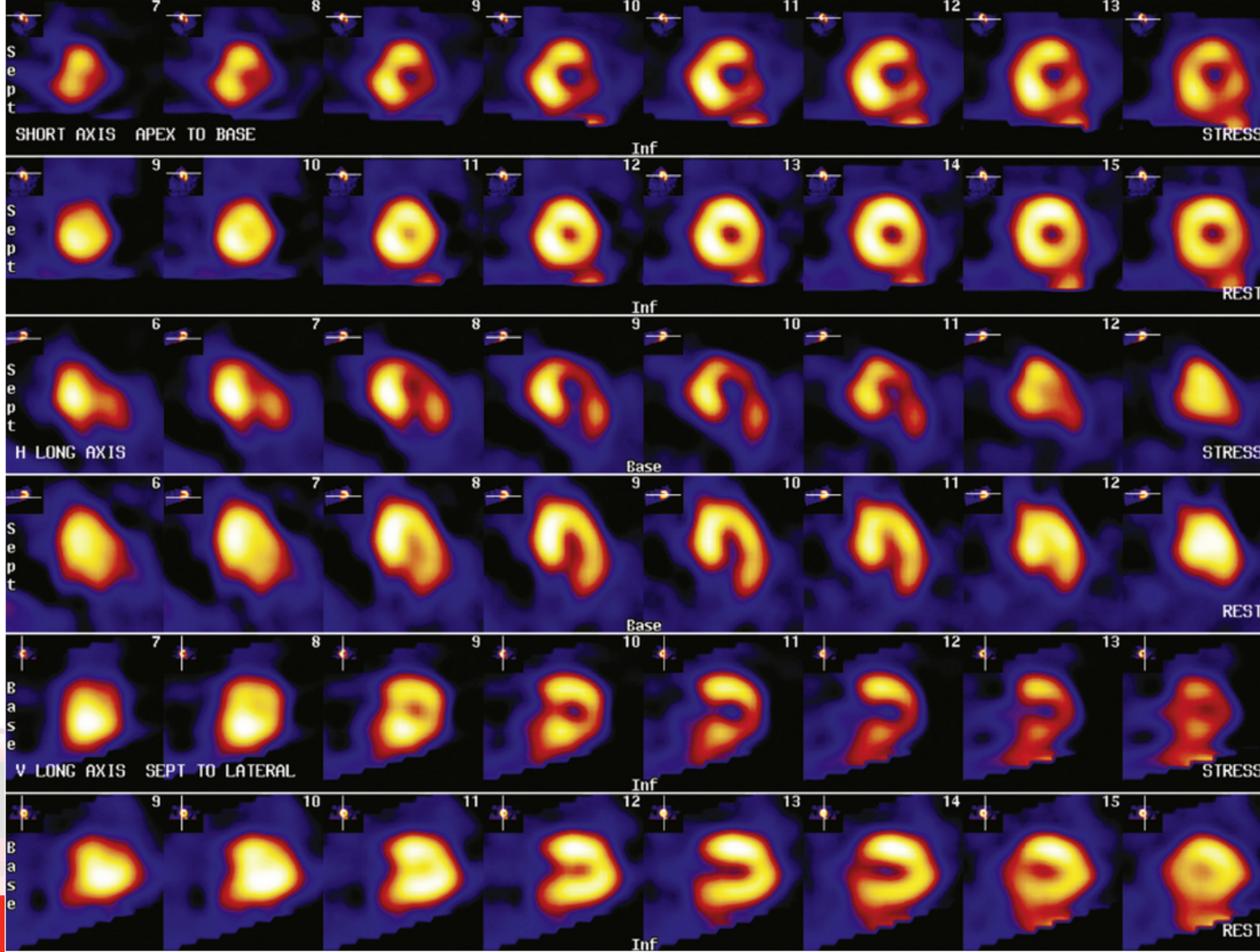
Case Study 1

- 76 y/o diabetic woman
- Pre-op for R fem-pop by-pass (foot ulcer)
- No complaint of chest pain but limited activity due to PVD


7 8 9 10 11 12 13
Sept
SHORT AXIS APEX TO BASE
Inf
STRESS
9 10 11 12 13 14 15
Sept
Inf
REST
6 7 8 9 10 11 12
Sept
H LONG AXIS
Base
STRESS
6 7 8 9 10 11 12
Sept
Base
REST
7 8 9 10 11 12 13
Base
V LONG AXIS SEPT TO LATERAL
Inf
STRESS
9 10 11 12 13 14 15
Base
Inf
REST

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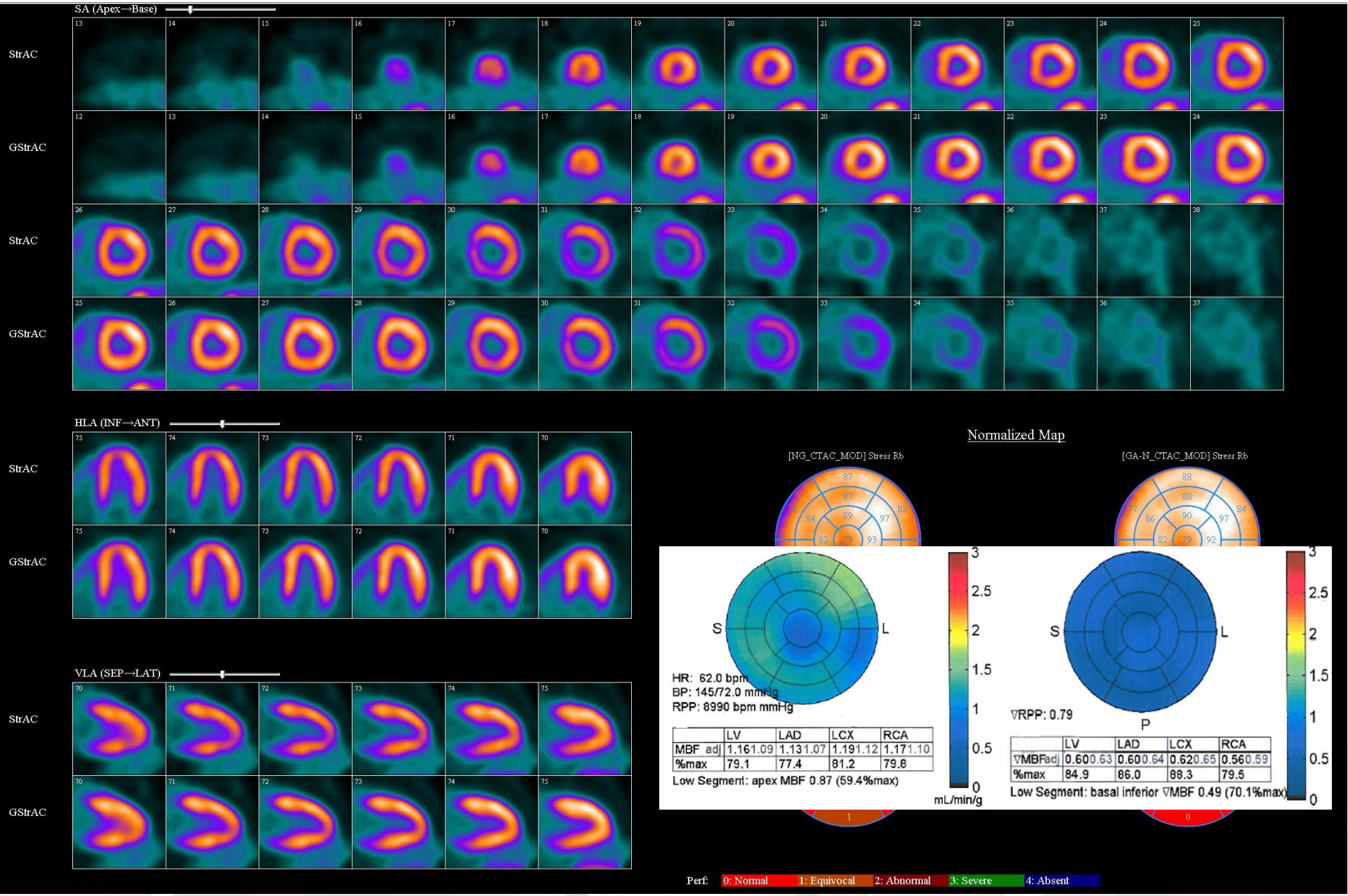
Case Study 3

- 59 y/o man chronic Hep C referred for MPI prior to liver transplant

- Smoker, no other risk factors


SA (Apex→Base)
StrAC
GStrAC
StrAC
GStrAC
HLA (INF→ANT)
StrAC
GStrAC
VLA (SEP→LAT)
StrAC
GStrAC
Normalized Map
[NG_CTAC_MOD] Stress Rb
[GA-N_CTAC_MOD] Stress Rb
S
L
HR: 62.0 bpm
BP: 145/72.0 mmHg
RPP: 8990 bpm mmHg
LV LAD LCX RCA
MBF adj 1.16 1.09 1.13 1.07 1.19 1.12 1.17 1.10
%max 79.1 77.4 81.2 79.8
Low Segment: apex MBF 0.87 (59.4%max)
3 2.5 2 1.5 1 0.5 0
mL/min/g
S
L
P
∇RPP: 0.79
LV LAD LCX RCA
∇MBFadj 0.60 0.63 0.60 0.64 0.62 0.65 0.56 0.59
%max 84.9 86.0 88.3 79.5
Low Segment: basal inferior ∇MBF 0.49 (70.1%max)
3 2.5 2 1.5 1 0.5 0
Perf: 0: Normal 1: Equivocal 2: Abnormal 3: Severe 4: Absent

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Why Do Pre-op Risk Assessment

- Do all patients need it?
- What tests should be used when indicated?
- Does every patient with an abnormal functional test need revascularization?
- What are the predictors of short and long term outcome?
- Does cardiac CT have a role in pre-op evaluation?

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What Renders Surgery Dangerous?

- Stress/Enhanced adrenergic drive/tachycardia
- Fluid shift
- Bleeding
- Imbalance between thrombosis and fibrinolysis
- Type of anesthesia

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Neuraxial Anesthesia for the Prevention of Postoperative Mortality and Major Morbidity: An Overview of Cochrane Systematic Reviews

Joanne Guay, MD,* Peter T. Choi, MD,† Santhanam Suresh, MD,‡ Natalie Albert, MD,§ Sandra Kopp, MD,‖ and Nathan Leon Pace, MD¶

Conclusions: Compared to general anesthesia, neuraxial anesthesia may reduce the 0-30 day mortality for patients undergoing a surgery with an intermediate-to-high cardiac risk (level of evidence moderate). Large randomized clinical trials are needed.

Anesth Analg 2014;119:716-25

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Factors to Consider in Pre-op Risk Assessment

- Clinical risk factors (symptomatic IHD, CHF, DM, CKD, CVA)

- Moderate to high surgical risk (vasc surgery, intra-thoracic, intra-abdominal, head&neck, orthopedic and prostate surgery)

- Poor (< 4METs) or unknown functional capacity

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Clinical Risk Scores

- Goldman et al (NEJM 1977; 297;845-50)
  - Active CV disease
  - Diabetes mellitus
  - Renal disease
- Lee et al (Circulation 1999;100:1043-49)
  - High risk surgery
  - hx of CAD
  - hx of CHF
  - hx of CVA
  - Insulin dependent DM
  - Serum Cr >2 mg/dl (>170 µmol/L)

Score 0: <1% event rate	74% of the patients
Score 1-2: 7% event rate	18% of the patients
Score ≥ 3: 11% event rate	8% of the patients

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Clinical Risk Scores

- Am College Surgeons-National Surg QIP (NSQIP_2011)
  - Age
  - Type of surgery
  - Functional status
  - Serum Cr >1.5 mg/dl (>130 µmol/L)
  - Am Society Anesthesiology Class I-V

http://www.surgicalriskcalculator.com/miorcardiacarrest

Advantage	Disadvantage
Predicts outcomes better in vascular surgery than the Lee score	Predicts only peri-op MI and cardiac death, while the Lee score predicts MI, death, pulmonary oedema and heart block

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Factors to Consider in Pre-op Risk Assessment

- Clinical risk factors (IHD, CHF, DM, CKD, CVA)
- Moderate to high surgical risk (supra-inguinal vasc surgery, intra-thoracic, intra-abdominal, head&neck, orthopedic and GU surgery)
- Poor (< 4METs) or unknown functional capacity

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Low-risk: < 1%	Intermediate-risk: 1–5%	High-risk: > 5%
• Superficial surgery • Breast • Dental • Endocrine: thyroid • Eye • Reconstructive • Carotid asymptomatic (CEA or CAS) • Gynaecology: minor • Orthopaedic: minor (meniscectomy) • Urological: minor (transurethral resection of the prostate)	• Intraperitoneal: splenectomy, hiatal hernia repair, cholecystectomy • Carotid symptomatic (CEA or CAS) • Peripheral arterial angioplasty • Endovascular aneurysm repair • Head and neck surgery • Neurological or orthopaedic: major (hip and spine surgery) • Urological or gynaecological: major • Renal transplant • Intra-thoracic: non-major	• Aortic and major vascular surgery • Open lower limb revascularization or amputation or thromboembolectomy • Duodeno-pancreatic surgery • Liver resection, bile duct surgery • Oesophagectomy • Repair of perforated bowel • Adrenal resection • Total cystectomy • Pneumonectomy • Pulmonary or liver transplant

2014 ESC/ESA Guidelines on non-cardiac surgery

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Periop. Cardiac Events in Vasc Surgery

		Incidence of	
Vascular Surgery	No. Patients	NFMI (%)	CV Death (%)
Young '77[73] 1958–68	75	12.5	8.0
1968–76	143	12.5	8.0
Hertzer '81[74] Aortic	343	N/A	6.1
Peripheral	273	N/A	3.3
Cutler '87[75]	116	7.8	0
Raby '89[76]	176	2.3	0.6
Eagle '89[26]	200	4.5	3.0
Younis '90[77]	111	3.6	3.6
Hendel '92[60]	327	6.7	2.1
Taylor '91[78]	491	3.5	0.8
Kresowik '93[79]	170	2.4	0.6
McFalls '93[80]	116	17.0	1.7
Baron '94[81]	457	4.8	2.2
Bry '94[82]	237	5.9	1.3
Seeger '94[83]	172 (no test)	1.1	0.6
	146 (test)	3.4	0.7
Fleisher '95[84]	109	3.7	0.9

Fom Beller and Zaret: Clinical Nuclear Cardiology, 4th Edition

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Factors to Consider in Pre-op Risk Assessment

- Clinical risk factors (IHD, CHF, DM, CKD, CVA)
- Moderate to high surgical risk (supra-inguinal vasc surgery, intra-thoracic, intra-abdominal, head&neck, orthopedic and GU surgery)
- Poor (< 4METs) or unknown functional capacity

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Combining Clinical and Thallium Data Optimizes Preoperative Assessment of Cardiac Risk Before Major Vascular Surgery

Conclusions:

Pre-operative DP-^{201}Th is most useful for intermediate risk patients

In patients with one or two clinical predictors an abnormal DP-^{201}Th correlates with probability of events

For nearly half the patients DP-^{201}Th is unnecessary

Eagle KA et al. Ann Int Med 1989;110:859-66

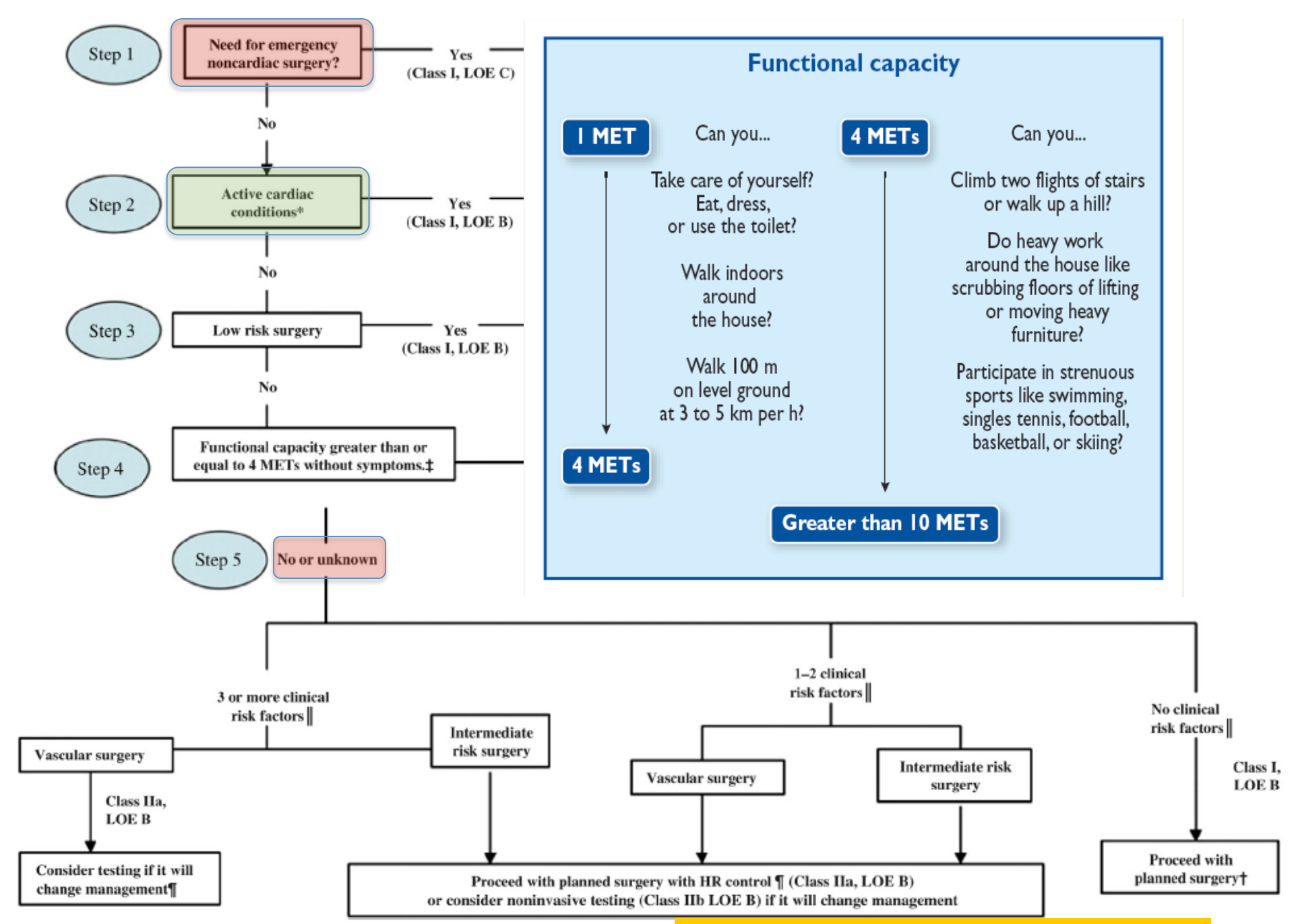

Figure 2. Stepwise Approach to Perioperative Cardiac Assessment

2013 ACC_AUC for Multimodality Imaging

Section 3. Pre-Operative Evaluation for Noncardiac Surgery

Table 3.1. Moderate-to-Good Functional Capacity (≥4 METs) OR No Clinical Risk Factors

Refer to pages 12 and 13 for relevant definitions								
Indication Text		Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
71.	• Any surgery	R	R	R	R	R	R	R

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.
CCTA = coronary computed tomography angiography; CMR = cardiac magnetic resonance; ECG = electrocardiogram; Echo = echocardiography; R = Rarely Appropriate; RNI = radionuclide imaging.

Table 3.2. Asymptomatic AND < 1 Year Post Any of the Following: Normal CT or Invasive Angiogram, Normal Stress Test for CAD, or Revascularization

Refer to pages 12 and 13 for relevant definitions								
Indication Text		Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
72.	• Any surgery	R	R	R	R	R	R	R

Table 3.3. Poor or Unknown Functional Capacity (<4 METs)

Refer to pages 12 and 13 for relevant definitions								
Indication Text		Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
73.	• Low-risk surgery • ≥1 clinical risk factor	R	R	R	R	R	R	R
74.	• Intermediate-risk surgery • ≥1 clinical risk factor	M	M	M	M	R	R	R
75.	• Vascular surgery • ≥1 clinical risk factor	M	A	A	M	R	R	R
76.	• Kidney transplant	M	A	A	M	R	R	M
77.	• Liver transplant	M	A	A	M	R	R	M

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Value of Pre-op Nuclear Screening

Author	Thallium Redist (%)	Periop Events MI/Dead (%)	Ischemia Pos. Pred (%)	Normal Scan Neg. Pred (%)
		Vascular Surgery Only		
Total (weighted avg)	42	7	12	99
2417 Total patients		14 studies		
		Other Surgery		
Total (weighted avg)	33	6	13	99
923 Total patients		6 studies		

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Gradient of MPI Criteria

- Very low risk: nl perfusion and LVEF
- Low risk: Small reversible or fixed perfusion defect
- Intermediate risk: moderate size rev or fixed perfusion defect w/o TID and ↑ lung uptake
- High risk: Large or multiple perfusion defects; moderate perfusion defects with TID and/or ↑ lung uptake; severely depressed LVEF

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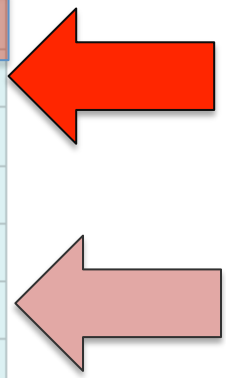
Long-Term Survival Predictors

	CUMULATIVE SURVIVAL			
	1 Yr (%)	2 Yr (%)	3 Yr (%)	5 Yr (%)
Screening Test				
White et al., 1988[58]				
Goldman risk index[11] (clinical)				
I (low)	98	90	84	78
II/III (intermediate)	84	78	66	46
IV (high)	55	40	30	18
Kazmers et al., 1988[63]				
Radionuclide ventriculogram				
≥35% LVEF	90	82	82	—
<35% LVEF	56	56	37	—
Hertzer 1987[53]				
CAD by angiography				
≤single vessel	97	95	92	85
≥double vessel	83	74	53	22
Cutler et al., 1992[64]				
Dipyridamole thallium-201 scan				
Normal scan	99	97	97	97
Fixed defect	88	79	69	55



Fom Beller and Zaret: Clinical Nuclear Cardiology, 4th Edition

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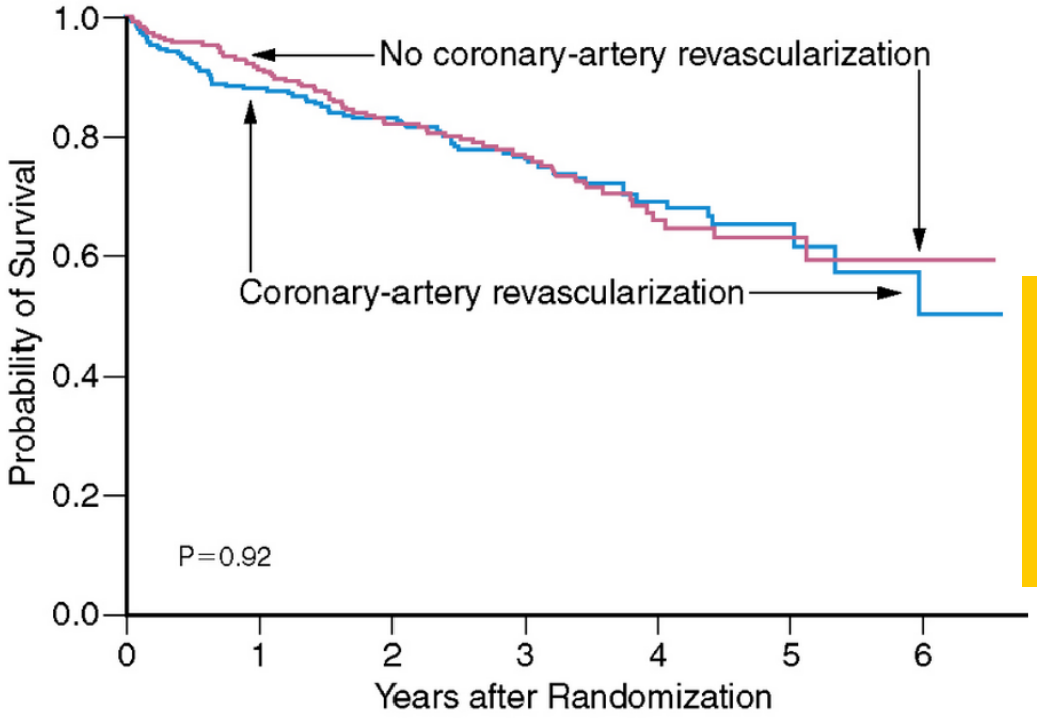
Revascularization?

Table 8 Summary of pre-operative cardiac risk evaluation and peri-operative management

Step	Urgency	Cardiac condition	Type of surgery[a]	Functional capacity	Number of clinical risk factors[b]	ECG	LV echo[c]	Imaging Stress Testing[d]	BNP and TnT[c]	ß-Blockers[e,ff]	ACE-inhibitors[e]	Aspirin[e]	Statins[e]	Coronary Revascula-risation
1	Urgent surgery	Stable					III C	III C		I B (continuation)	IIa C[h] (continuation)	IIb B (continuation)	I C (continuation)	III C
2	Urgent surgery	Unstable[g]												IIa C
	Elective surgery	Unstable[g]				I C[g]	I C[g]	III C	IIb B					I A
3	Elective surgery	Stable	Low risk (< 1%)		None	III C	III C	III C	III C	III B	IIa C[h]	I C[m]	IIa B[j]	III B
					≥ 1	IIb C	III C	III C		IIb B[i]	IIa C[h]	I C[m]	IIa B[j]	III B
4	Elective surgery	Stable	Intermediate (1–5%) or high risk (>5%)	Excellent or good			III C	III C	III C	IIb B[i]	IIa C[h]	I C[m]	IIa B[j]	III B
5	Elective surgery	Stable	Intermediate risk (1–5 %)	Poor	None	IIb C	III C[k]		III C[k]	IIb B[i]	IIa C[h]	I C[m]	IIa B[j]	III B
					≥ 1	I C	III C[k]	IIb C		IIb B[i]	IIa C[h]	I C[m]	IIa B[j]	III B
6	Elective surgery	Stable	High risk (>5 %)	Poor	1–2	I C	IIb C[k]	IIb C	IIb B[i,k]	IIb B[ij]	IIa C[h]	I C[m]	IIa B[j]	IIb B
					≥ 3	I C	IIb C[k]	I C	IIb B[k]	IIb B[ij]	IIa C[h]	I C[m]	IIa B[j]	IIb B

Benefit of Pre-Op Revascularization



No. at Risk

Revascularization	226	175	113	65	18	7
No revascularization	229	172	108	55	17	12

Exclusions:

*Left main disease
*Severe aortic stenosis
*LVEF<20%

McFalls et al *N Engl J Med.* 2004; 351:2795-2804

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Pre-Transplant Evaluation

Guidelines and Recommendations

- **2012 AHA Scientific Statement**
  - Noninvasive stress testing may be considered on the basis of the presence of multiple CAD risk factors regardless of functional status (Class IIb, Level of Evidence C). Relevant risk factors include DM, prior CVD, 1 y on dialysis, LVH, age 60 y, smoking, hypertension, and dyslipidemia; the specific number of risk factors that should be used to prompt testing remains to be determined, but the committee considers 3 to be reasonable
- **2007 ACC/AHA Guidelines for Noncardiac Surgery**
  - If functional status 4 METS or unknown, then consider noninvasive stress testing if any of the following clinical risk factors: prior CVD, DM, and renal insufficiency.
  - Testing is recommended if 3 clinical risk factors are present. Testing may be considered in those with 1–2 risk factors
- **2007 Lisbon Conference**
  - There are no data establishing that screening of asymptomatic patients prevents cardiac events; noninvasive and/or invasive testing should be considered in highest-risk patients : DM, prior CVD, 1 y on dialysis, LVH, age 60 y, smoking, hypertension, and dyslipidemia. Does not specify the number of risk factors to justify testing
- **2001 AST Guidelines**
  - Noninvasive stress testing recommended for patients at “high risk”: DM, prior history of IHD, or 2 risk factors (Age>50y, hypertension, dyslipidemia)
- **2005 NKF/KDOQI Guidelines**
  - Noninvasive stress testing recommended for all transplant candidates every 12 to 36 mo according to CVD risk: DM, prior CAD, 2 traditional risk factors, LVEF 40%, and PVD

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EXPERT CONSENSUS DOCUMENT

Cardiac Disease Evaluation and Management Among Kidney and Liver Transplantation Candidates

A Scientific Statement From the American Heart Association and the American College of Cardiology Foundation

Recommendation for Testing prior to Kidney Tx

1. Noninvasive stress testing may be considered in kidney transplantation candidates with no active cardiac conditions based on the presence of multiple CAD risk factors regardless of functional status.
2. Relevant risk factors: DM, prior CVD, more than 1 year on dialysis, LVH, age >60 years, smoking, HTN, and dyslipidemia.
3. The specific number of risk factors that should be used to prompt testing remains to be determined, but the committee considers 3 or more as reasonable (***Class IIb; Level of Evidence C***)

Recommendation for Type of Testing

Sensitivity: DSE 44% to 89% MPI 29% to 92%
Specificity: DSE 71% to 94% MPI 67% to 89% for ≥1 stenosis ≥70%

The usefulness of noncontrast CT calcium scoring and cardiac CT angiography is uncertain for the assessment of pretransplantation cardiovascular risk (*Class IIb; Level of Evidence B*)

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A Call to Action: Variability in Guidelines for Cardiac Evaluation before Renal Transplantation

Scott E. Friedman, Robert T. Palac,* David M. Zlotnick,* Michael C. Chobanian,† and Salvatore P. Costa**

Summary

Background and objectives Candidates for renal transplantation are at increased risk for complications related to cardiovascular disease; however, the optimal strategy to reduce this risk is not clear. The aim of this study was to evaluate the variability among existing guidelines for preoperative cardiac evaluation of renal transplant candidates.

Design, setting, participants, & measurements A consecutive series of renal transplant candidates (n = 204) were identified, and four prominent preoperative cardiac evaluation guidelines, pertaining to this population, were retrospectively applied to determine the rate at which each guideline recommended cardiac stress testing.

Results The rate of pretransplant cardiac stress testing would have ranged from 20 to 100% depending on which guideline was applied. The American Heart Association/American College of Cardiology (ACC/AHA) guideline resulted in the lowest rate of testing (20%). In our population, 178 study subjects underwent stress testing: 17 were found to have ischemia and 10 underwent revascularization. The ACC/AHA approach would have decreased the number of noninvasive tests from 178 to 39; it would have identified only 4 of the 10 patients who underwent revascularization. The three other guidelines (renal transplant–specific guidelines) recommended widespread pretransplant cardiac testing and thus identified nearly all patients who had ischemia on stress testing.

Conclusions The ACC/AHA perioperative guideline may be inadequate for identifying renal transplant candidates with coronary disease; however, renal transplant–specific guidelines may provoke significant overtesting. An intermediate approach based on risk factors specific to the ESRD population may optimize detection of coronary disease and limit testing.

Clin J Am Soc Nephrol 6: 1185–1191, 2011. doi: 10.2215/CJN.09391010

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EXPERT CONSENSUS DOCUMENT

Cardiac Disease Evaluation and Management Among Kidney and Liver Transplantation Candidates

A Scientific Statement From the American Heart Association and the American College of Cardiology Foundation

Recommendation for Testing in pre-liver tx

1. Noninvasive stress testing may be considered in liver transplantation candidates with no active cardiac conditions on the basis of the presence of multiple CAD risk factors regardless of functional status.
2. Relevant risk factors: DM, prior CVD, LVH, age >60, smoking, HTN, dyslipidemia
3. The number of risk factors remains to be determined, but the committee considers 3 or more to be reasonable (***Class IIb; Level of Evidence C***)

It may be reasonable for each program to identify a primary cardiology consultant for questions related to potential liver transplantation candidates (***Class IIb; Level of Evidence B***)

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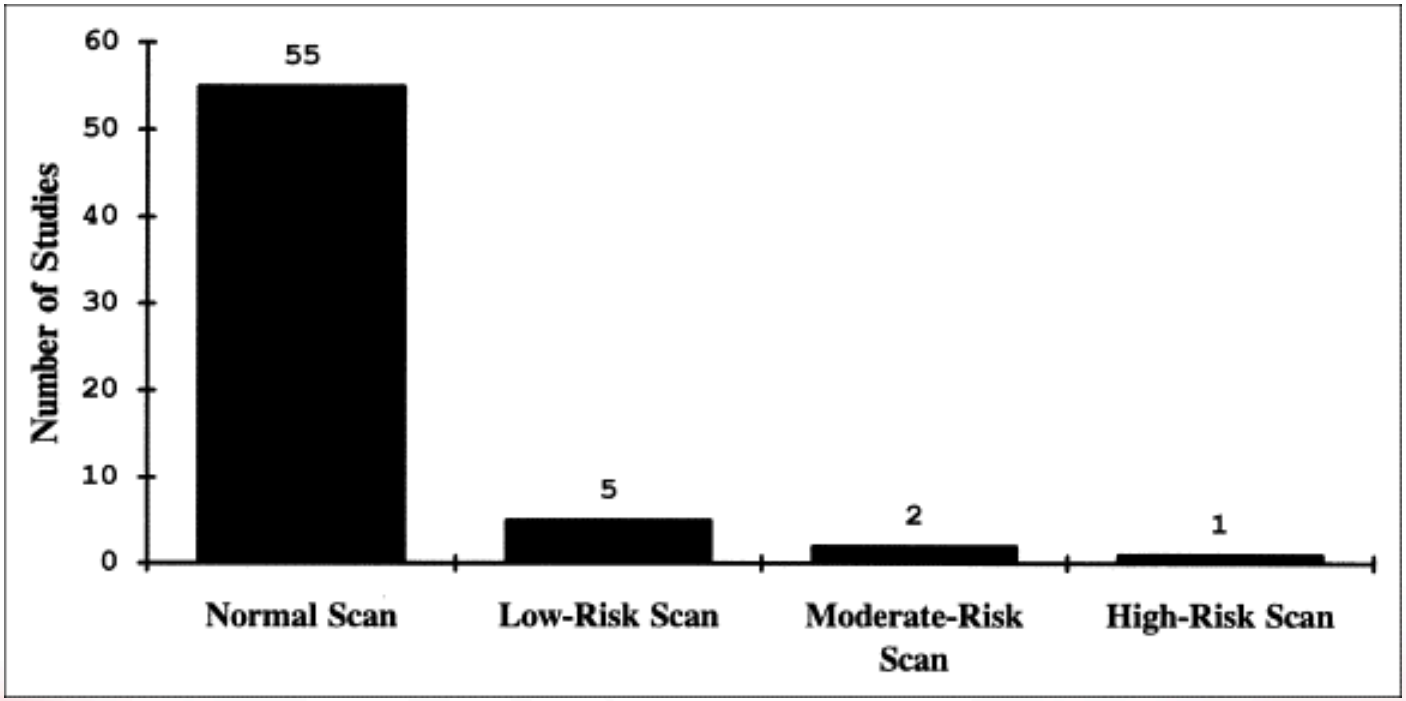
Usefulness of Preoperative Noninvasive Radionuclide Testing for Detecting Coronary Artery Disease in Candidates for Liver Transplantation



Kryzhanovski V, Beller G. Am J Cardiol 1997: 79:986 - 988

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Management of Obstructive CAD in Pre-Liver Tx

Extremely high mortality rates for patients with CAD (in early reports ~50-80% mortality at 1-3 years)

CABG is marred by very high morbidity and mortality in ESLD patients

A small series of 5 patients attempted liver TX simultaneous with CABG with 100% Tx success rate and 80% 35 month survival rate*

*Axelrod et al. Liver Transplant 2004;10:1386

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Computed Tomography for Pre-op Evaluation

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CTA for pre-op clearance

- Prior to TAVR/AVR/MVR
- Endocarditis to r/o CAD
- Prior to re-operation to gauge distance of the LIMA from the sternum

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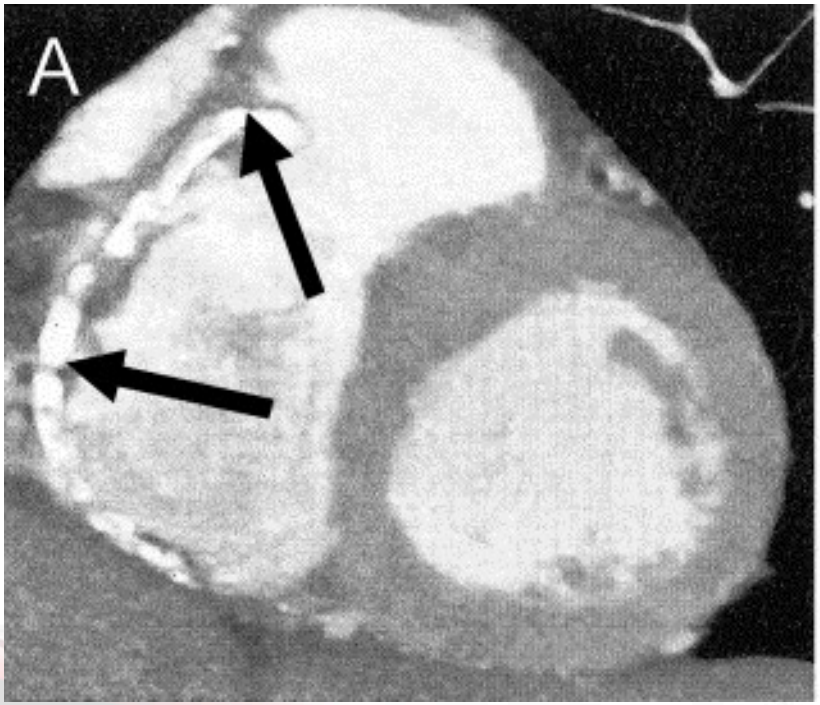
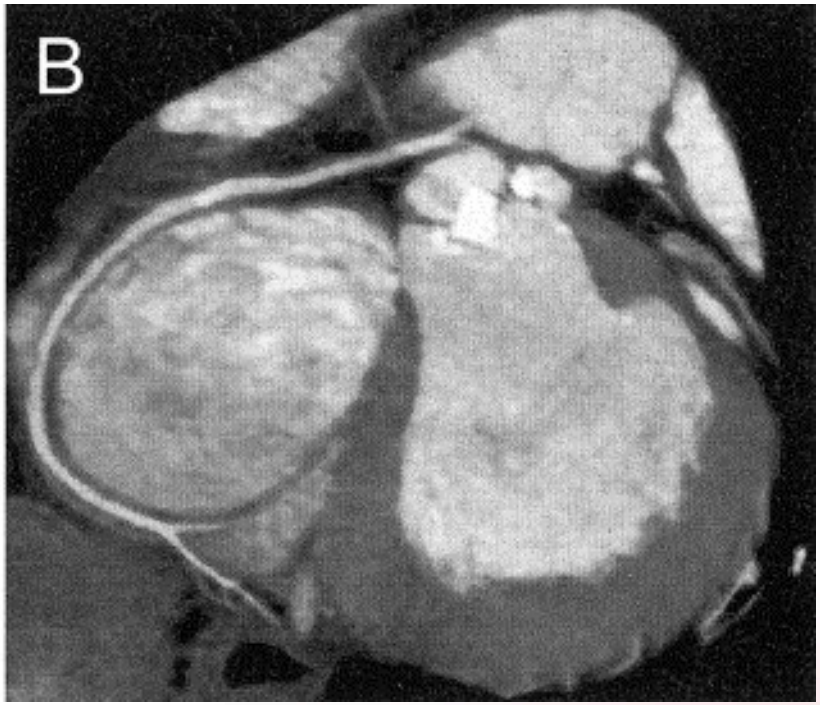
Accuracy of multislice computed tomography in the preoperative assessment of coronary disease in patients with **aortic valve stenosis**





55 patients with severe AS

Gilard M et al. J Am Coll Cardiol 2006;47:2020–4

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Pre-Operative Computed Tomography Coronary Angiography to Detect Significant Coronary Artery Disease in Patients Referred for Cardiac Valve Surgery

Willem B. Meijboom, MD,*† Nico R. Mollet, MD, PHD,*† Carlos A. G. Van Mieghem, MD,*†

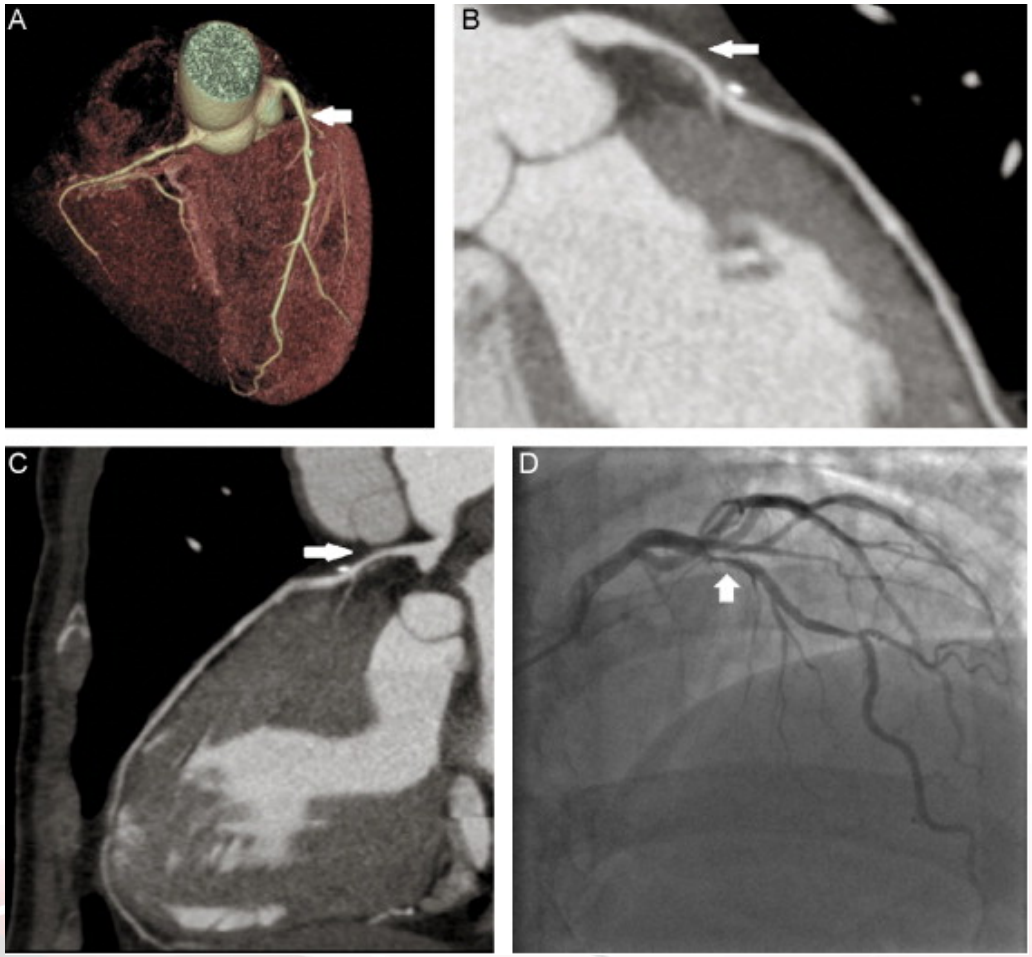
Table 3. Diagnostic Performance and Predictive Value of 64-Slice CTCA for the Detection of ≥50% Stenosis on QCA

	Prevalence of Disease, %	n	Sensitivity, %	Specificity, %	PPV, %	NPV, %
Patient-based analysis	25.7	70	100 (78–100)	92 (81–98)	82 (59–94)	100 (91–100)
Vessel-based analysis	9.3	280	100 (84–100)	97 (94–99)	76 (58–89)	100 (98–100)
RCA	14.3	70	100 (66–100)	97 (84–99)	83 (51–97)	100 (92–100)
LM	0.0	70	—	100 (94–100)	—	100 (94–100)
LAD	14.3	70	100 (66–100)	90 (79–96)	63 (36–84)	100 (92–100)
Cx	8.6	70	100 (52–100)	100 (93–100)	100 (52–100)	100 (93–100)
Segment-based analysis	3.6	1,003	94 (80–99)	98 (97–99)	65 (51–78)	100 (99–100)
Patient-based sub-analysis						
AP	38.1	21	100 (60–100)	92 (62–100)	89 (51–99)	100 (70–100)
No AP	20.4	49	100 (66–100)	92 (78–98)	77 (46–98)	100 (88–100)
AS	29.0	31	100 (63–100)	86 (64–96)	75 (43–93)	100 (79–100)
No AS	23.1	39	100 (63–100)	97 (81–100)	90 (54–99)	100 (85–100)

female; mean age 63 ± 11 years).

Accuracy of multislice computed tomography in the preoperative assessment of coronary disease in patients scheduled for heart valve surgery

48 patients



Jakamy R et al. Arch Cardiovasc Dis 2012;105:424-9

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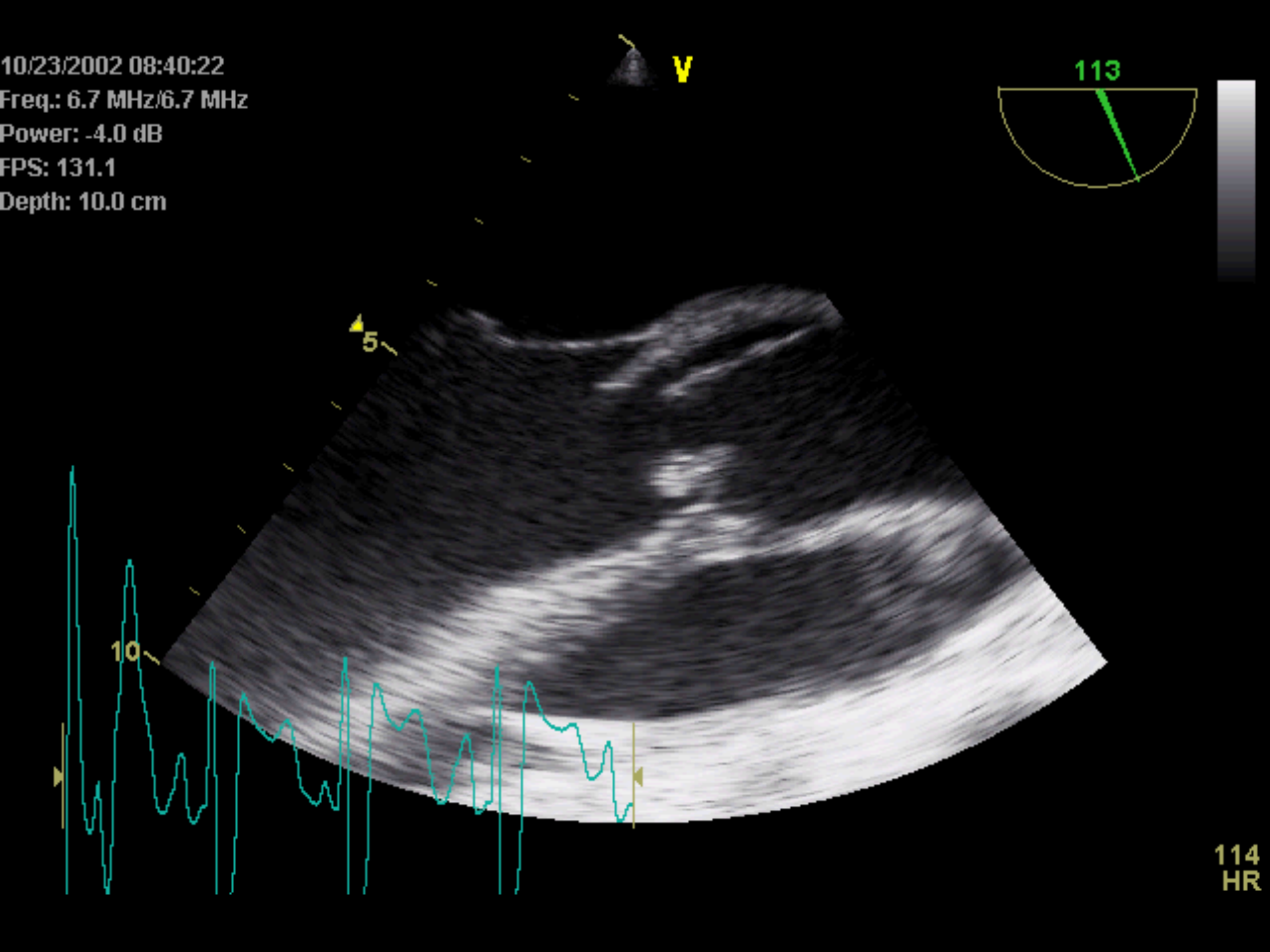
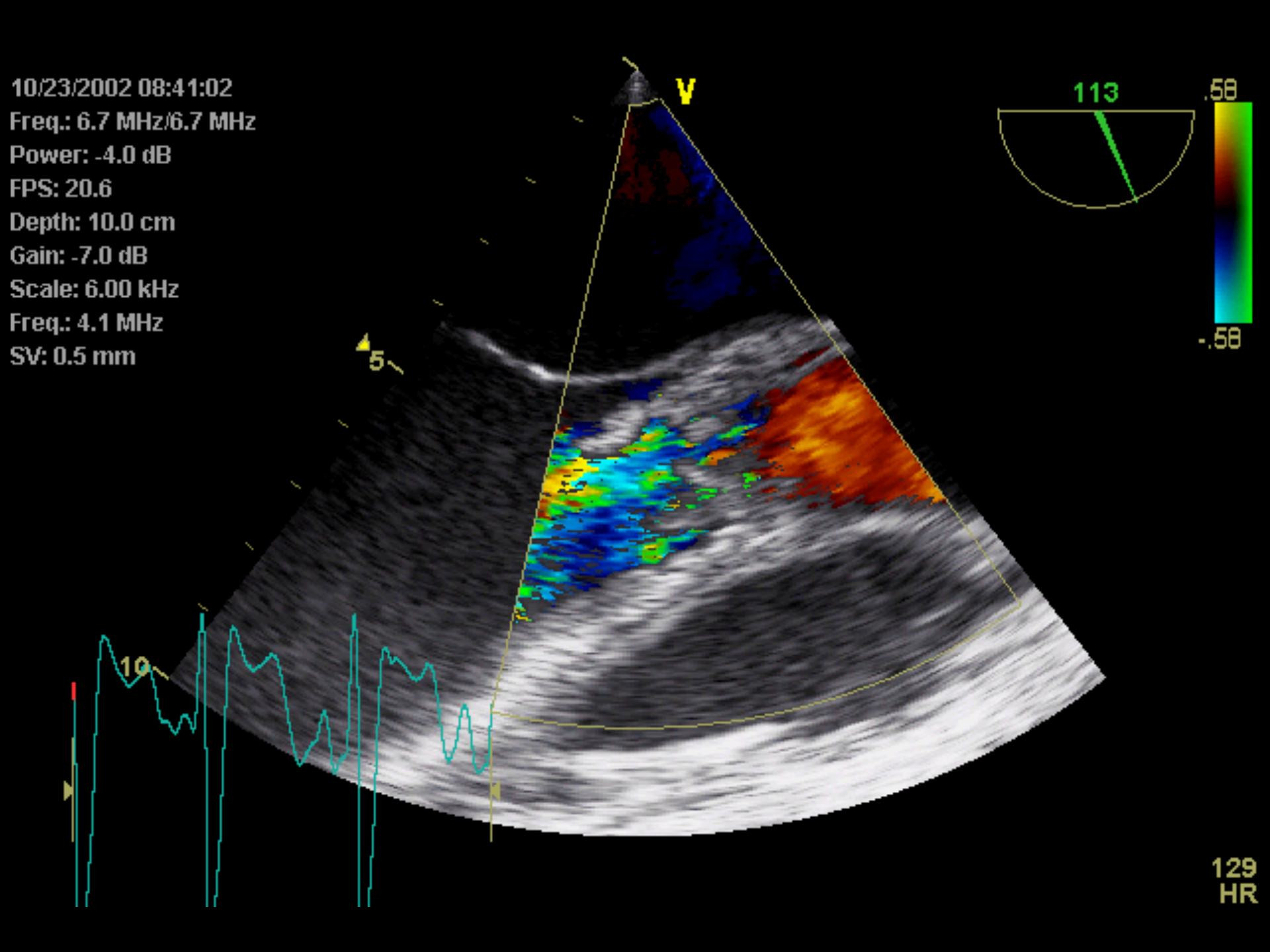
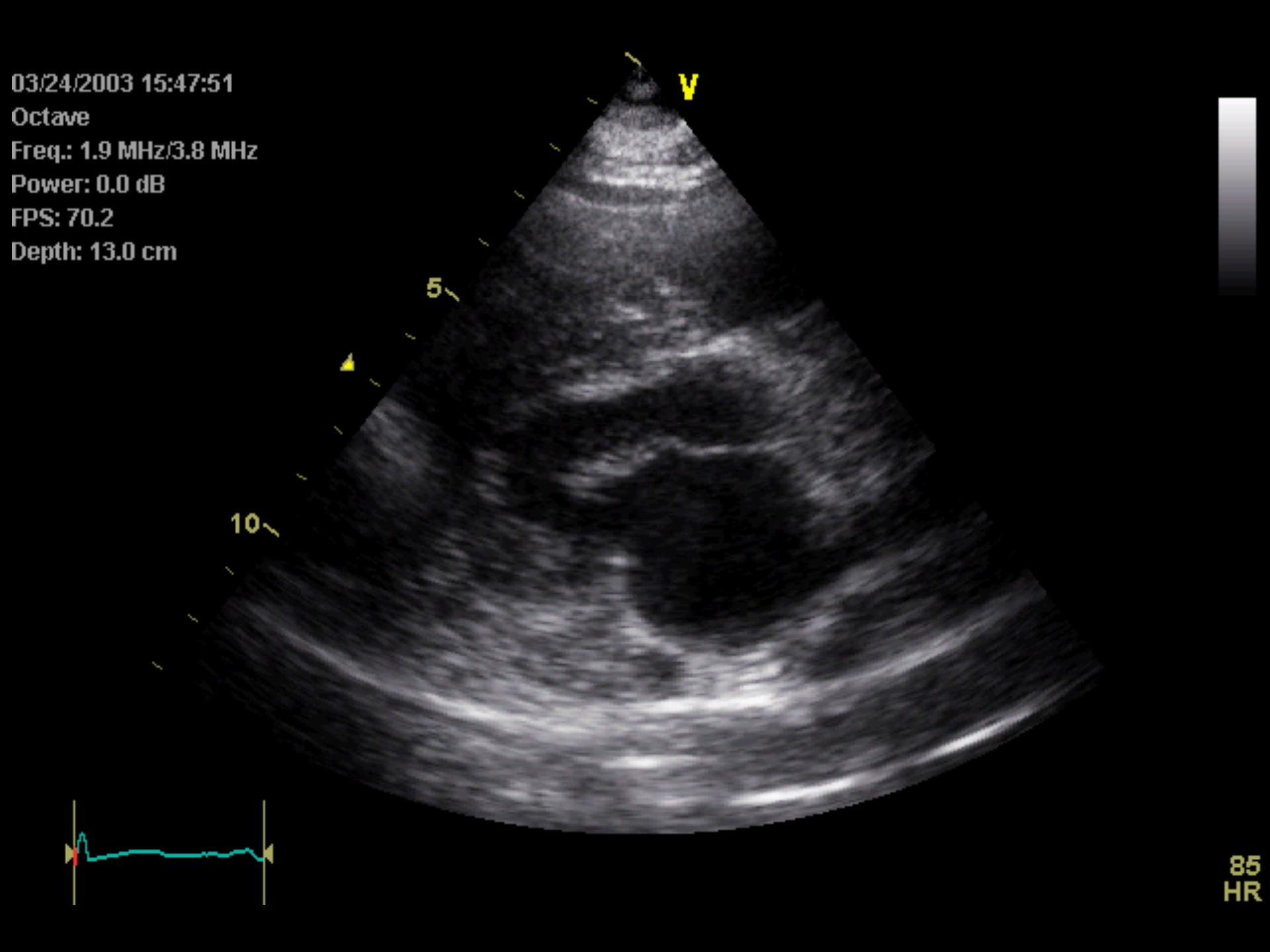
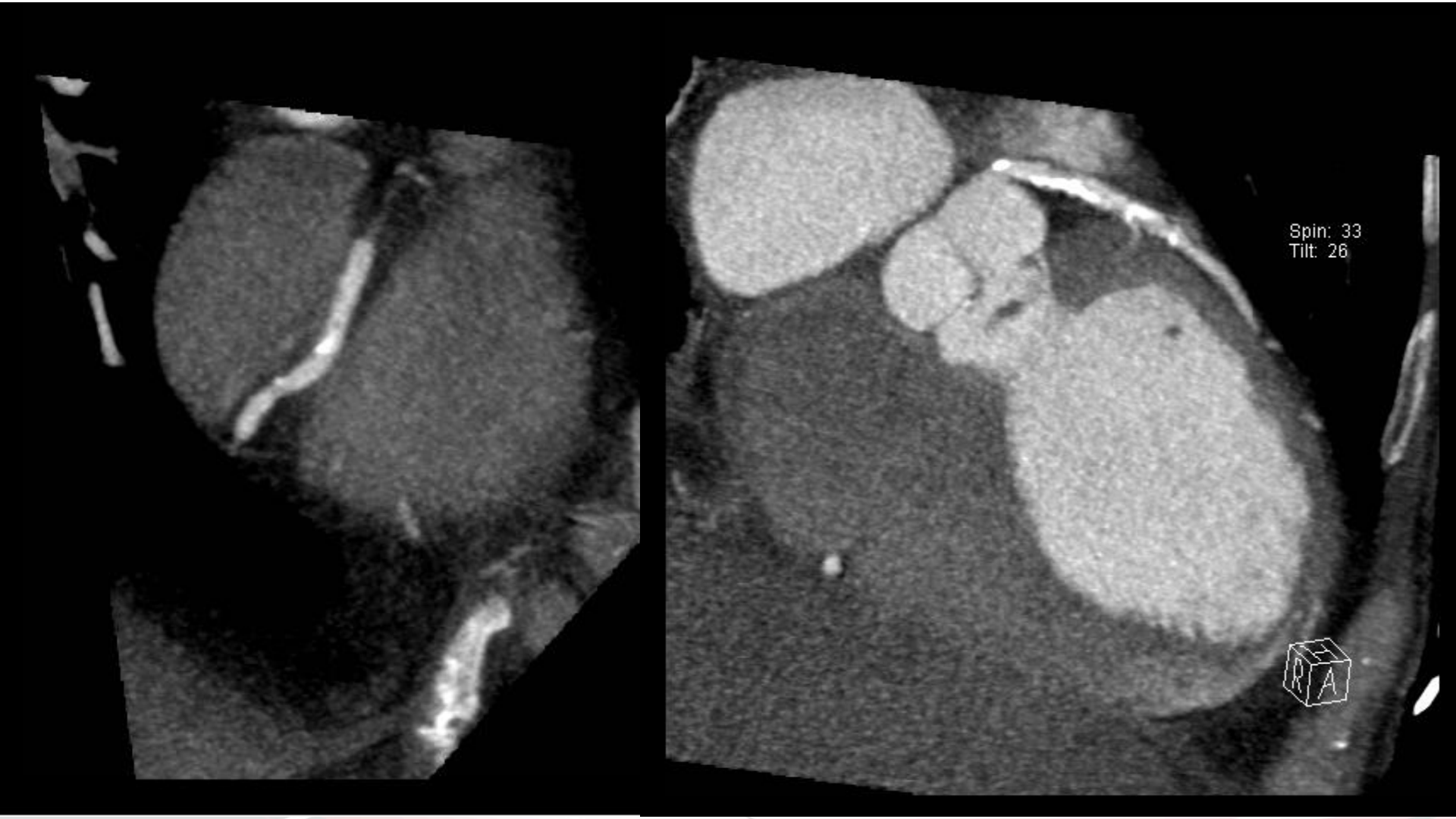
CASE STUDY

- 76 year old man, smoker
- Bi-valvular endocarditis with 2 large AoV vegetations and a massive MV vegetation
- An invasive angiogragm is requested for pre-op clearance


10/23/2002 08:40:22
Freq.: 6.7 MHz/6.7 MHz
Power: -4.0 dB
FPS: 131.1
Depth: 10.0 cm
V
113
5
10
114
HR


10/23/2002 08:41:02
Freq.: 6.7 MHz/6.7 MHz
Power: -4.0 dB
FPS: 20.6
Depth: 10.0 cm
Gain: -7.0 dB
Scale: 6.00 kHz
Freq.: 4.1 MHz
SV: 0.5 mm
V
5
10
113
.58
-.58
129
HR


03/24/2003 15:47:51
Octave
Freq.: 1.9 MHz/3.8 MHz
Power: 0.0 dB
FPS: 70.2
Depth: 13.0 cm
V
5
10
85
HR


Spin: 33
Tilt: 26
R
A

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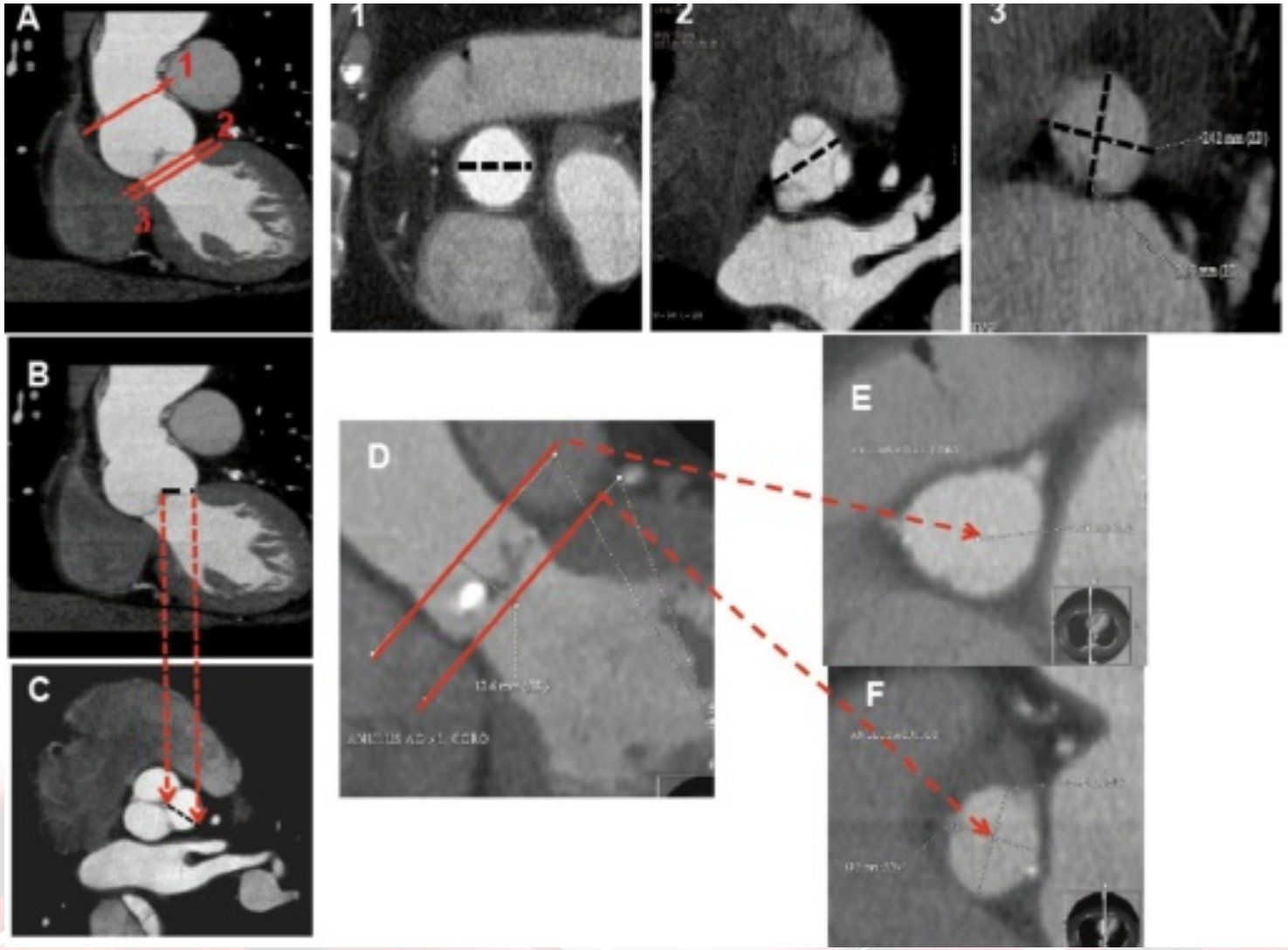
CTA pre-TAVI



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Conclusions[1]

- Testing in not necessary for the majority of patients
- Testing should be performed if results will influence pre-op management
- The majority of pre-op management can/ should be medical

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Conclusions$_2$

- MPI and DSE are well established techniques each with advantages and disadvantages
- Testing in pre-Tx remains a conundrum
- CT for pre-op evaluation can be helpful in limited circumstances