Stress Echocardiography;Which Method?

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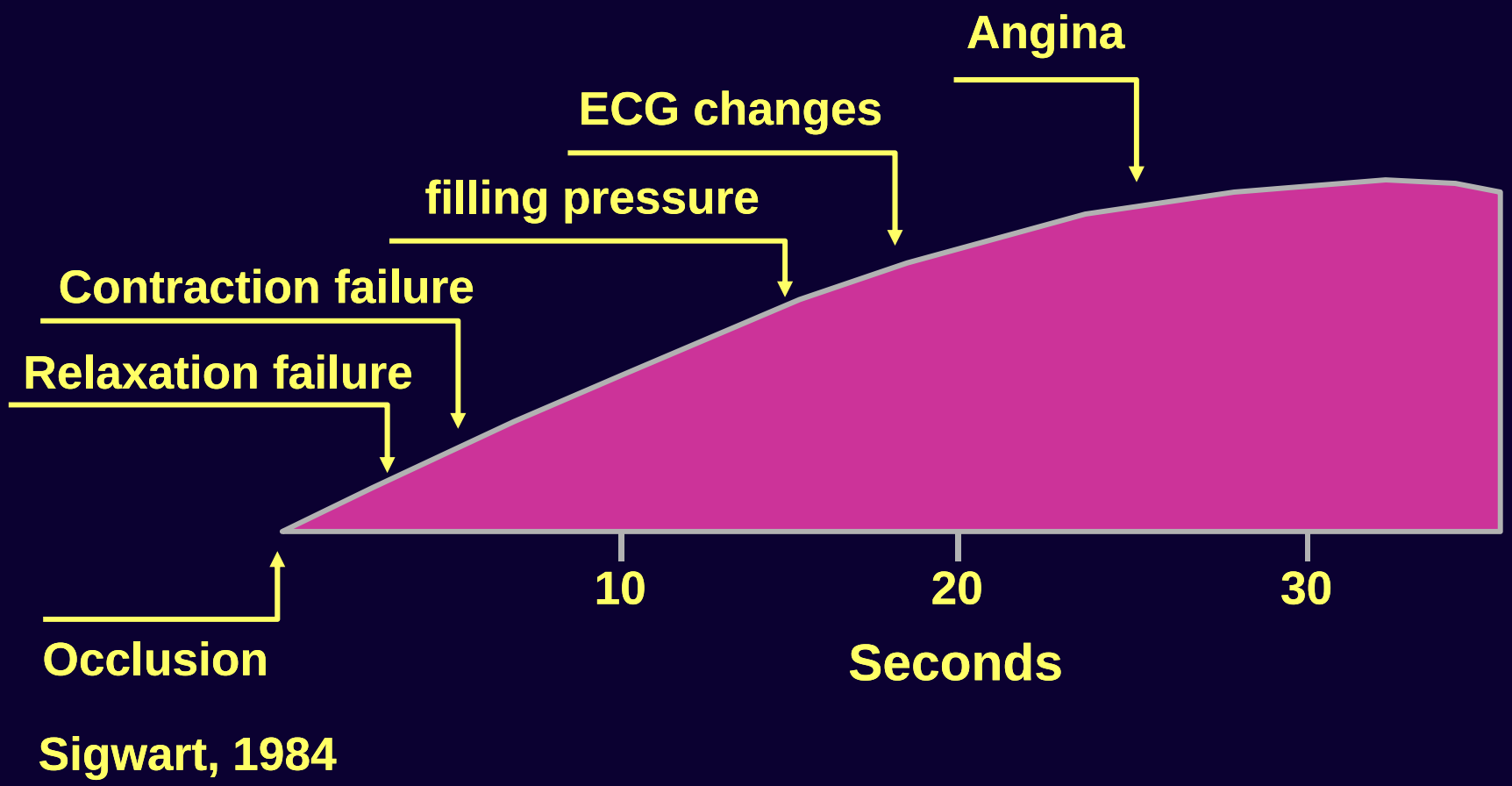
Sequence of Events During PTCA

Ischemic Cascade



Sigwart, 1984

Stress Modalities

Exercise

- Treadmill
- Bicycle – upright or supine

Pharmacologic

- Dobutamine
- Dipyridamole
- Adenosine
- Ergonovine

Other

- Transesophageal atrial pacing
- Combined modalities

Echo Parameter

Regional wall motion

Doppler parameters

- **Diastolic function of LV**
- **Coronary flow reserve (CFR)**
- **Myocardial velocity**
- **Strain, Strain rate**

Other

- **2-D strain, strain rate**
- **Perfusion with contrast agent**

Qantitative Assessment

- May be future
- Simplification for measurement
- More validation

ASE guideline 2007

Exercise vs Nonexercise

A patient's exercise capacity carries prognostic information, independent of demonstration of ischemia

McCully: JACC, 1998 (exercise echo)
Goraya: Ann Int Med, 2000 (exercise ECG)

Exercise Echocardiography

- Detection of CAD
- Quantification of CAD
- Prognostic value

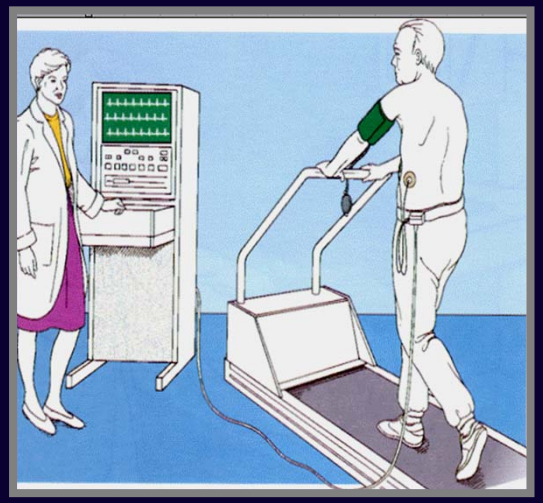
Exercise Echo
Protocol

- Baseline images
- Baseline HR, BP, ECG
- Symptom-limited exercise test. BP, HR, ECG monitoring
- Post-exercise (peak for bicycle) images
- Side by side display of rest and stress images

TMET Stress Echo

Advantages

- Physiologic
- ECG predictable
- Exercise information
- 2 sets of Images



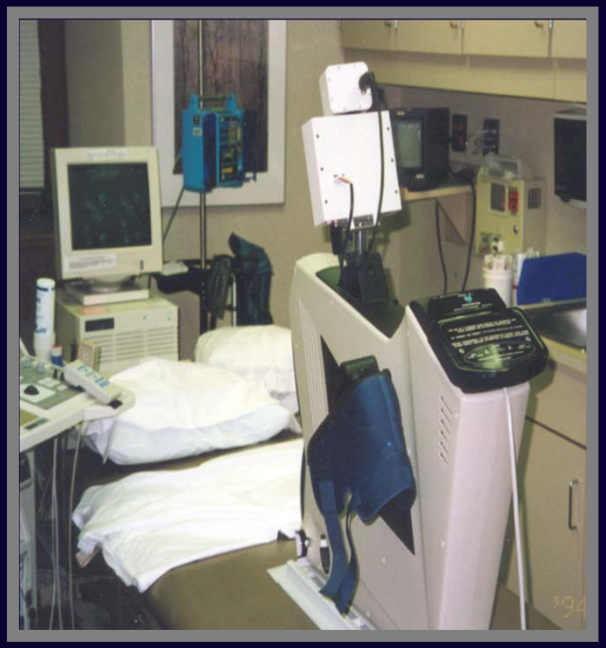
Disadvantages

- Must be able to walk
- ? Reach target HR
- Peak images only and may be difficult

Bicycle Stress Echo

Advantages

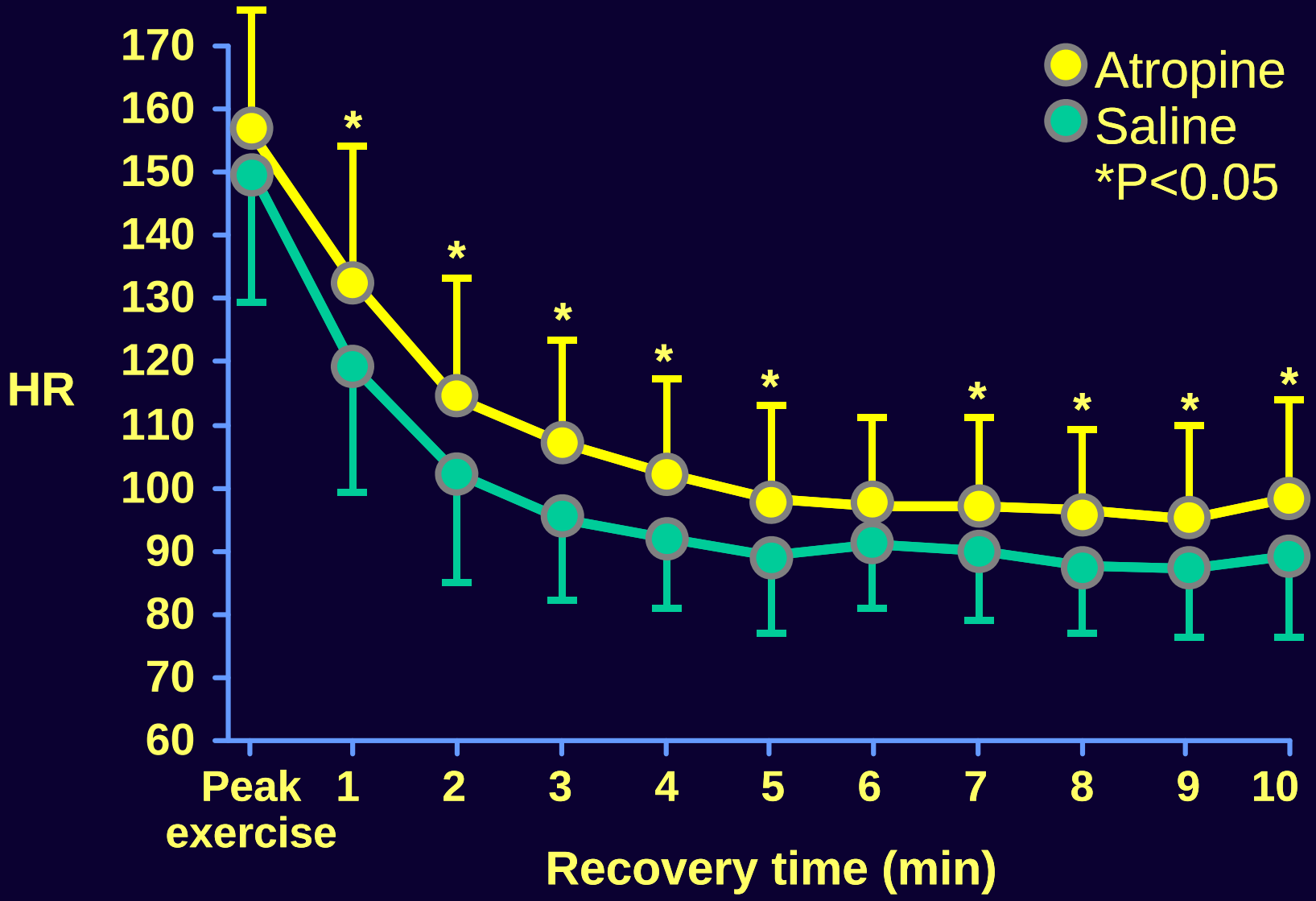
- Continuous Imaging
- Ischemic threshold
- Hemodynamics
- ? Detect more ischemia



Disadvantages

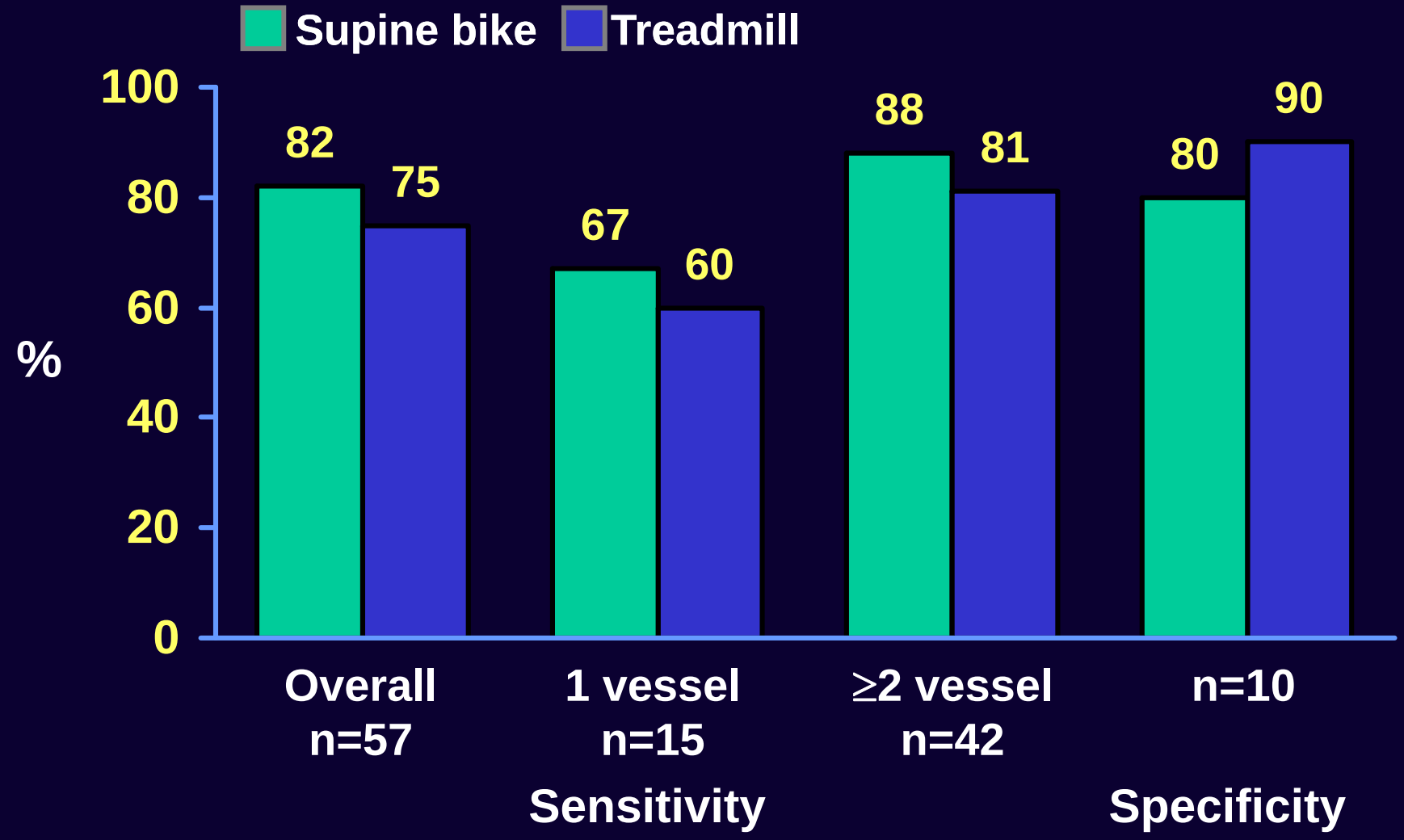
- Exercise awkward
- Lower work load
- HR lower, BP higher

Heart Rate Decline After Exercise



Attenhoffer et al: Echocardiography, 2000

Sensitivity and Specificity of Supine Bike vs Treadmill Exercise Echo



Badruddin et al: JACC, 1999

Dobutamine Stress Echo

Advantages

- No exercise
- Target HR reached
- Continuous imaging
- Ischemic threshold
- Hemodynamics
- Viability
- Images easier

Disadvantages

- Not as physiologic
- Low dose - contractility
- High dose - HR
- Need IV
- Dynamic LVOT
- Arrhythmias

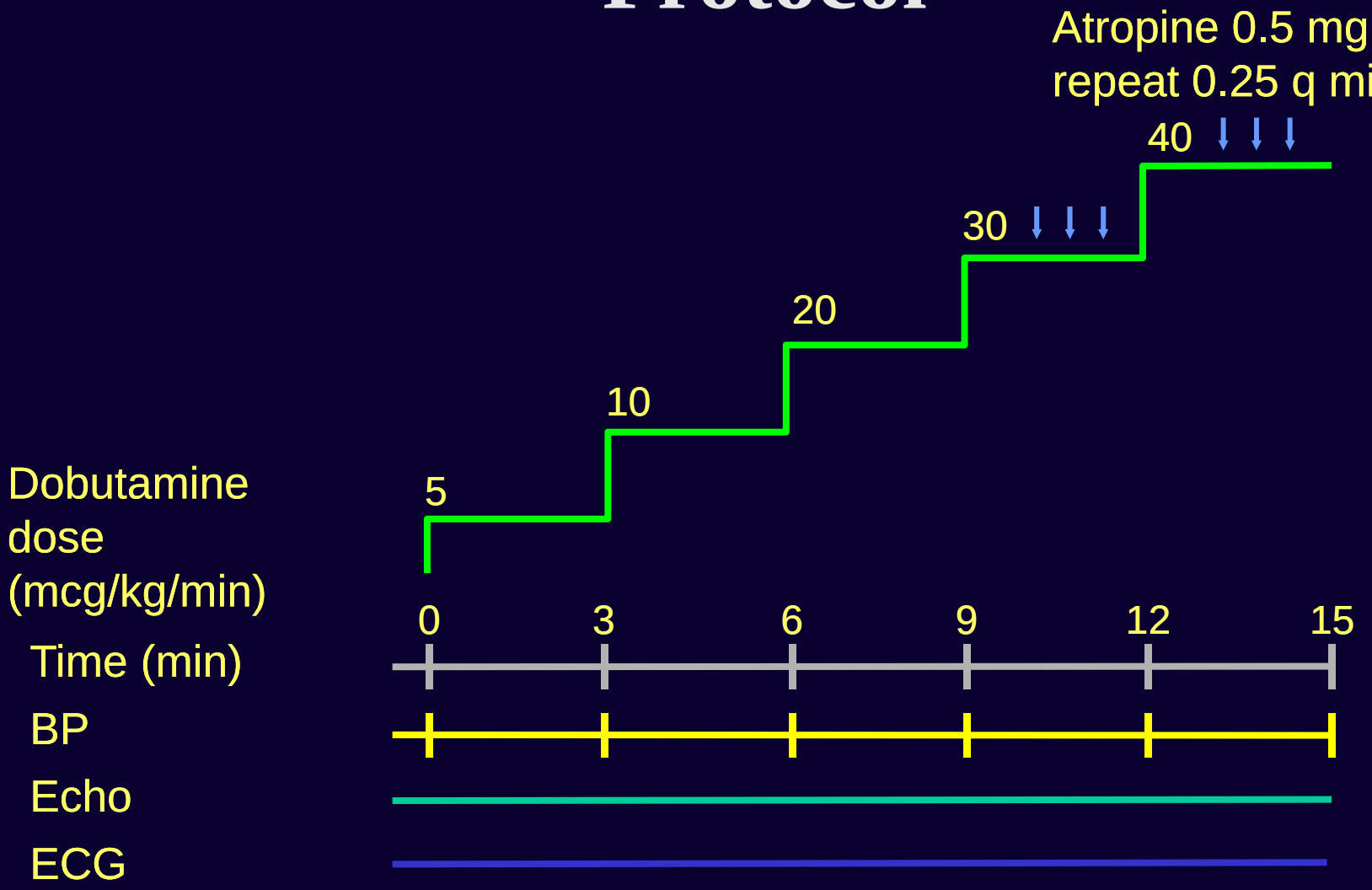
Dobutamine Pharmacology

- Synthetic catecholamine, B1
- Increases myocardial oxygen demand
  - Increases contractility
  - Increases heart rate
- Half-life 2 minutes

Dobutamine Stress Echo
Contraindications

- **Dobutamine**
  - Uncontrolled hypertension
  - Uncontrolled dysrhythmia
- **Atropine**
  - Untreated narrow angle glaucoma
  - Severe urinary retention

Dobutamine Stress Echo Protocol

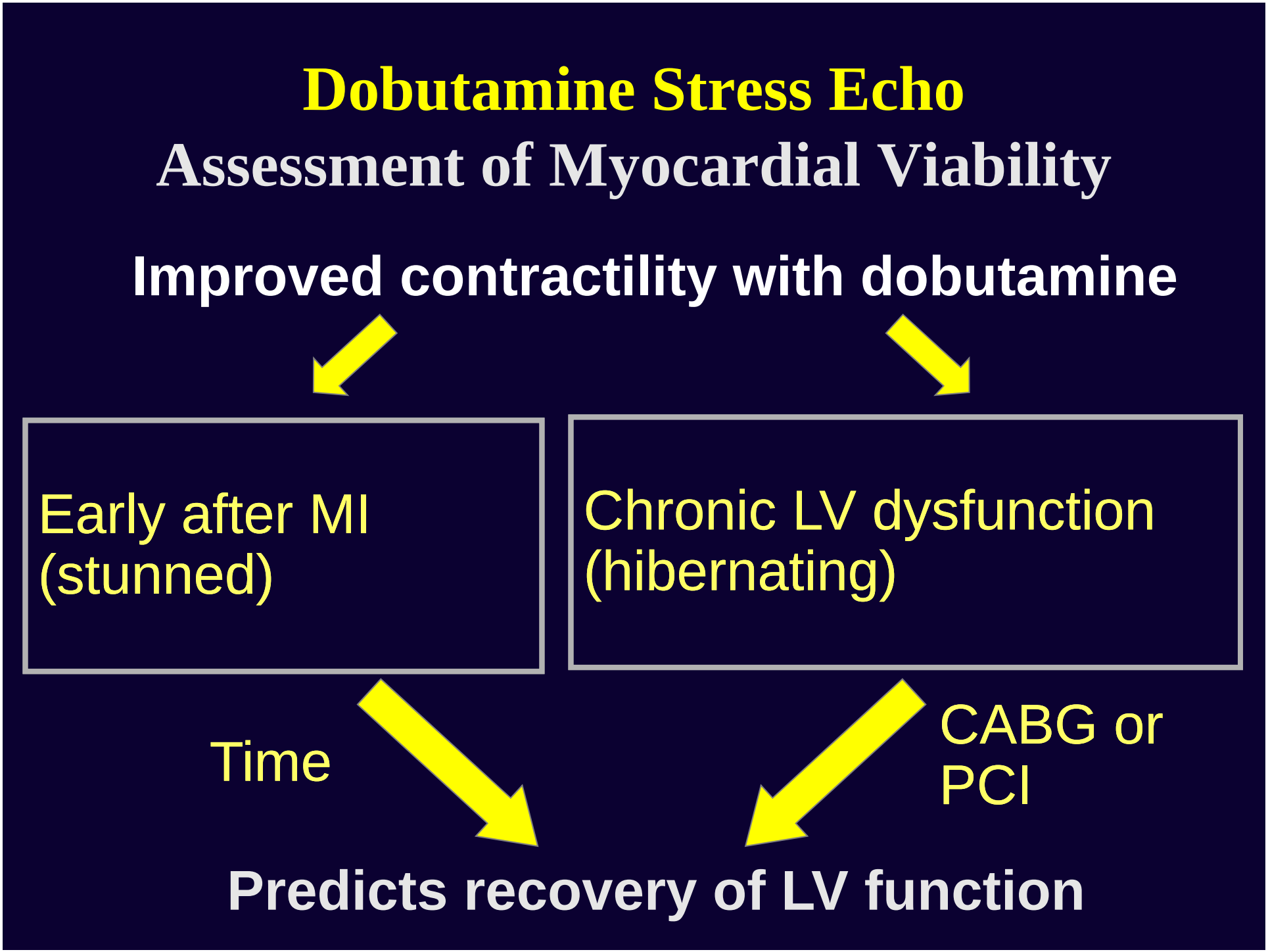


Dobutamine Stress Echo
Endpoints

- Peak dose
- Target heart rate .85 (220-age)
- Moderate or extensive wall motion abnormalities
- Significant arrhythmia
- Hypotension, severe hypertension
- Intolerable symptoms

Dobutamine-side effects

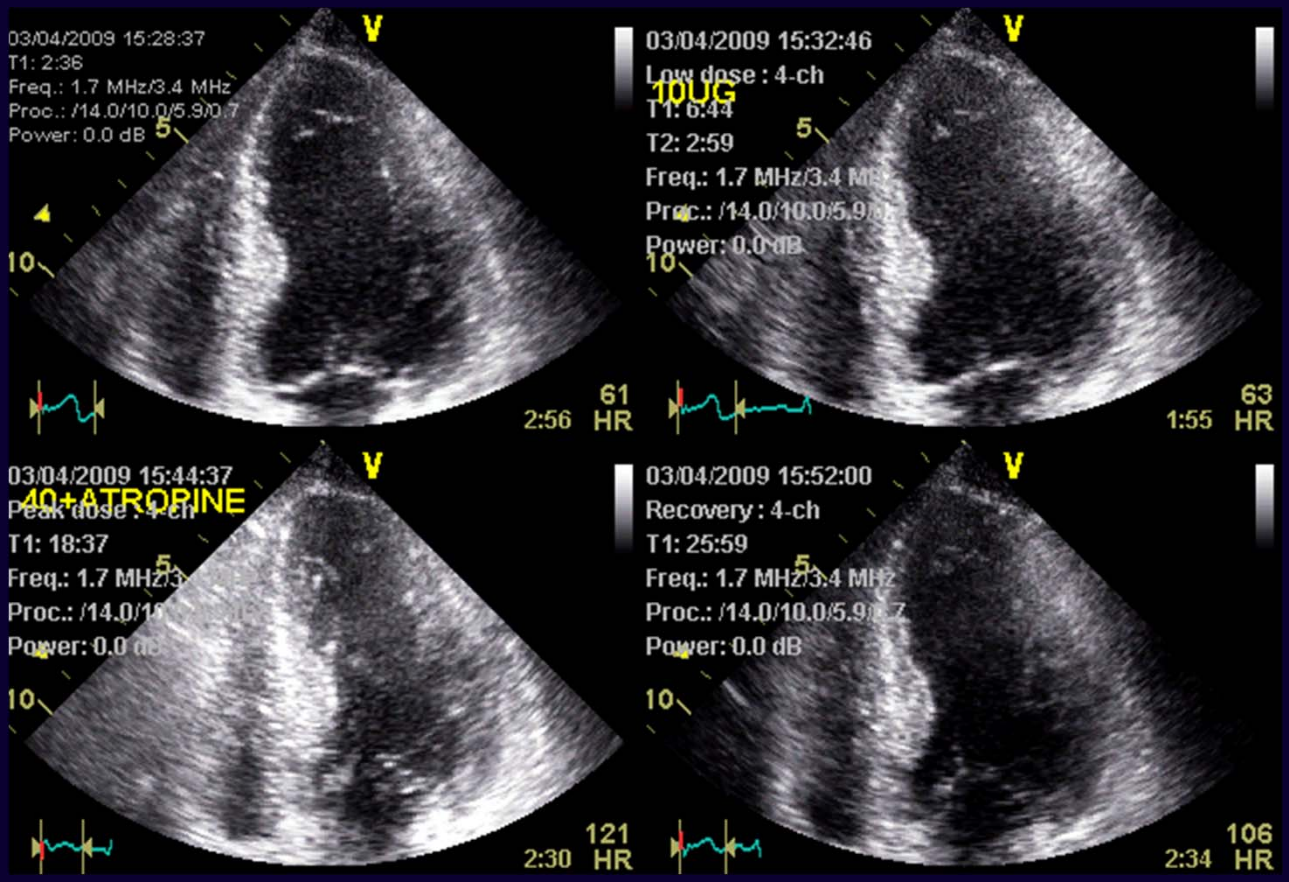
- Palpitations
- Chest pain
- Tremor or shivering
- Headache
- Urinary urgency
- Nausea
- Dyspnea
- Lightheadedness
- Hypertension, hypotension
- Arrhythmias


Dobutamine Stress Echo
Assessment of Myocardial Viability
Improved contractility with dobutamine
Early after MI (stunned)
Chronic LV dysfunction (hibernating)
Time
CABG or PCI
Predicts recovery of LV function

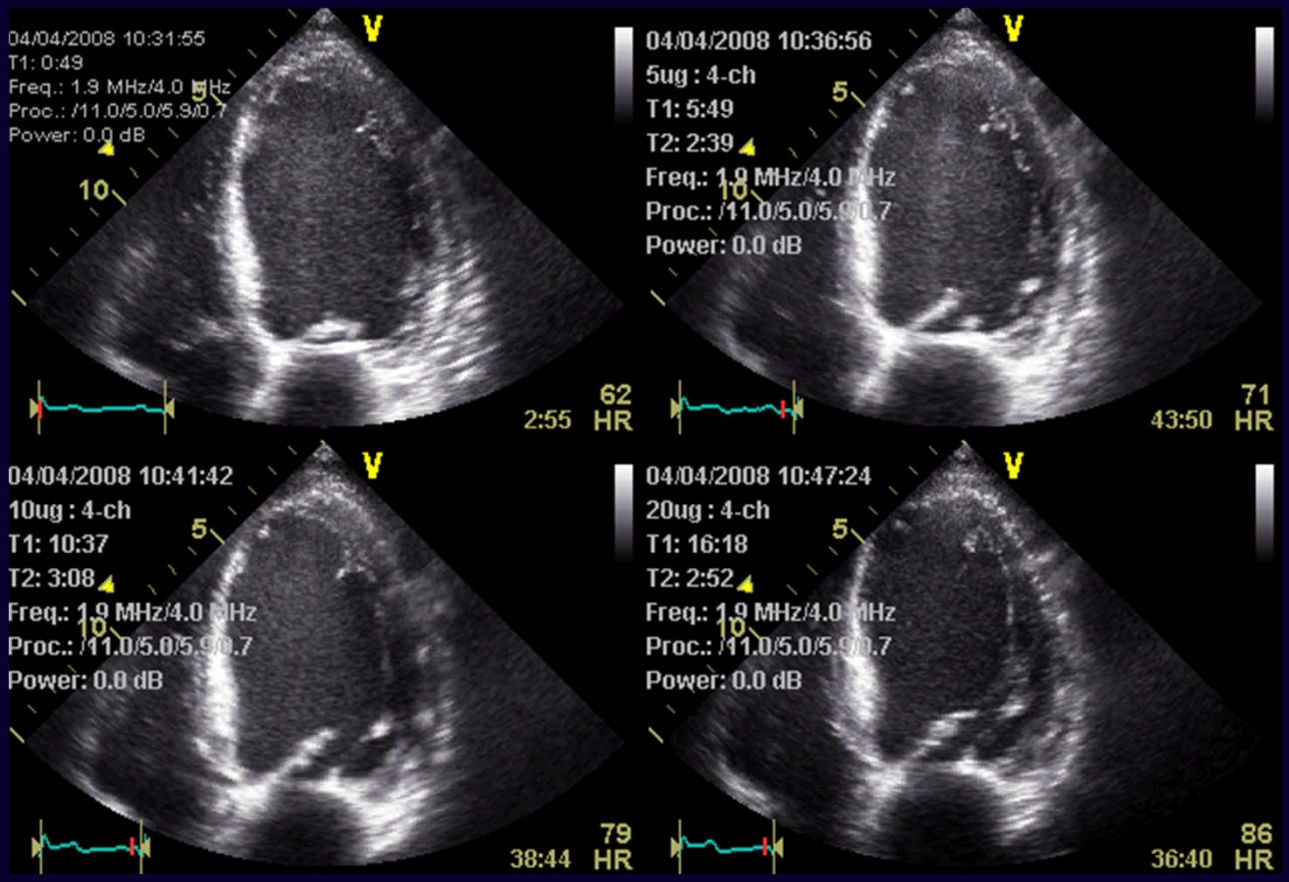
Myocardial Viability

Dobutamine Stress Echocardiography

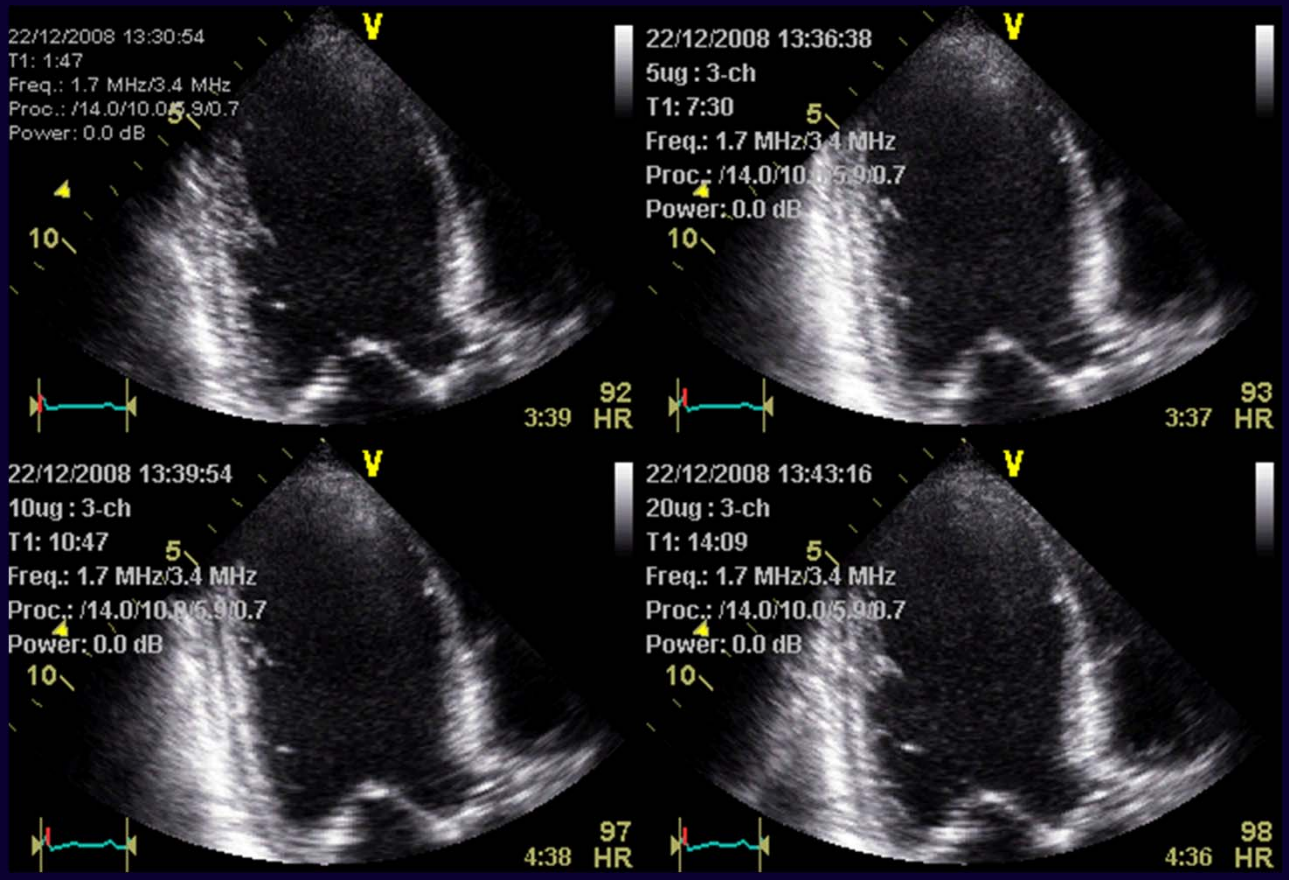
Normal Response in DSE



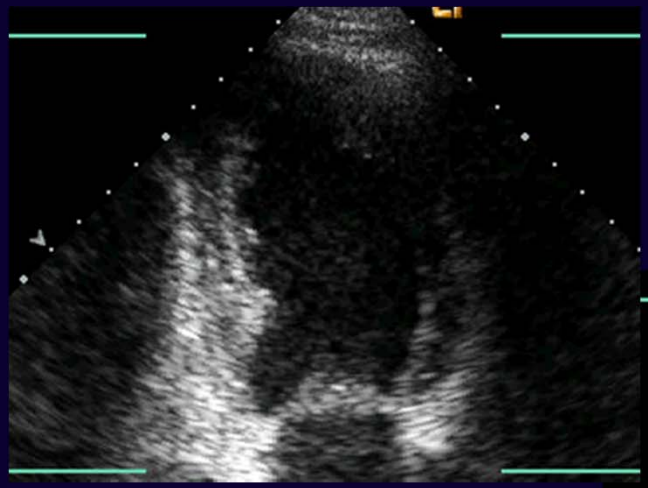
Stunned Myocardium in DSE



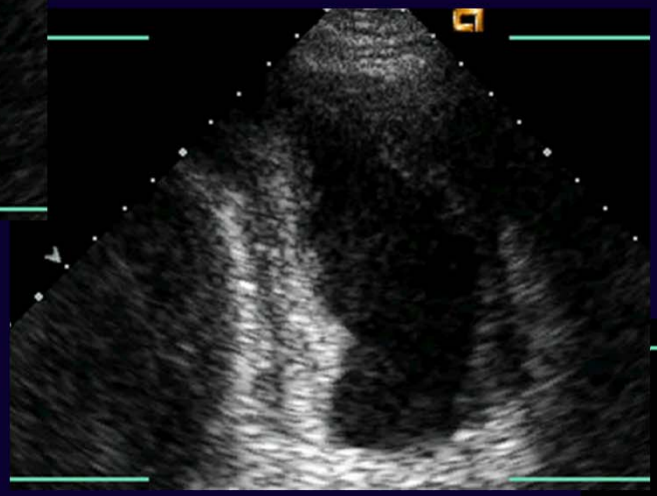
Nonviable Myocardium in DSE



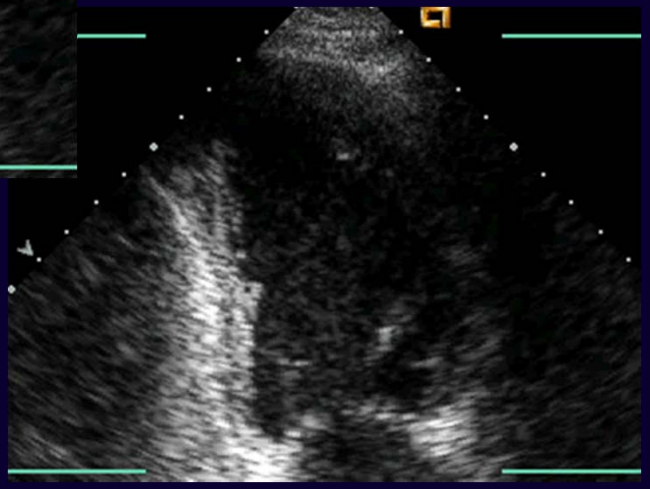
Hibernating Myocardium in DSE



Baseline



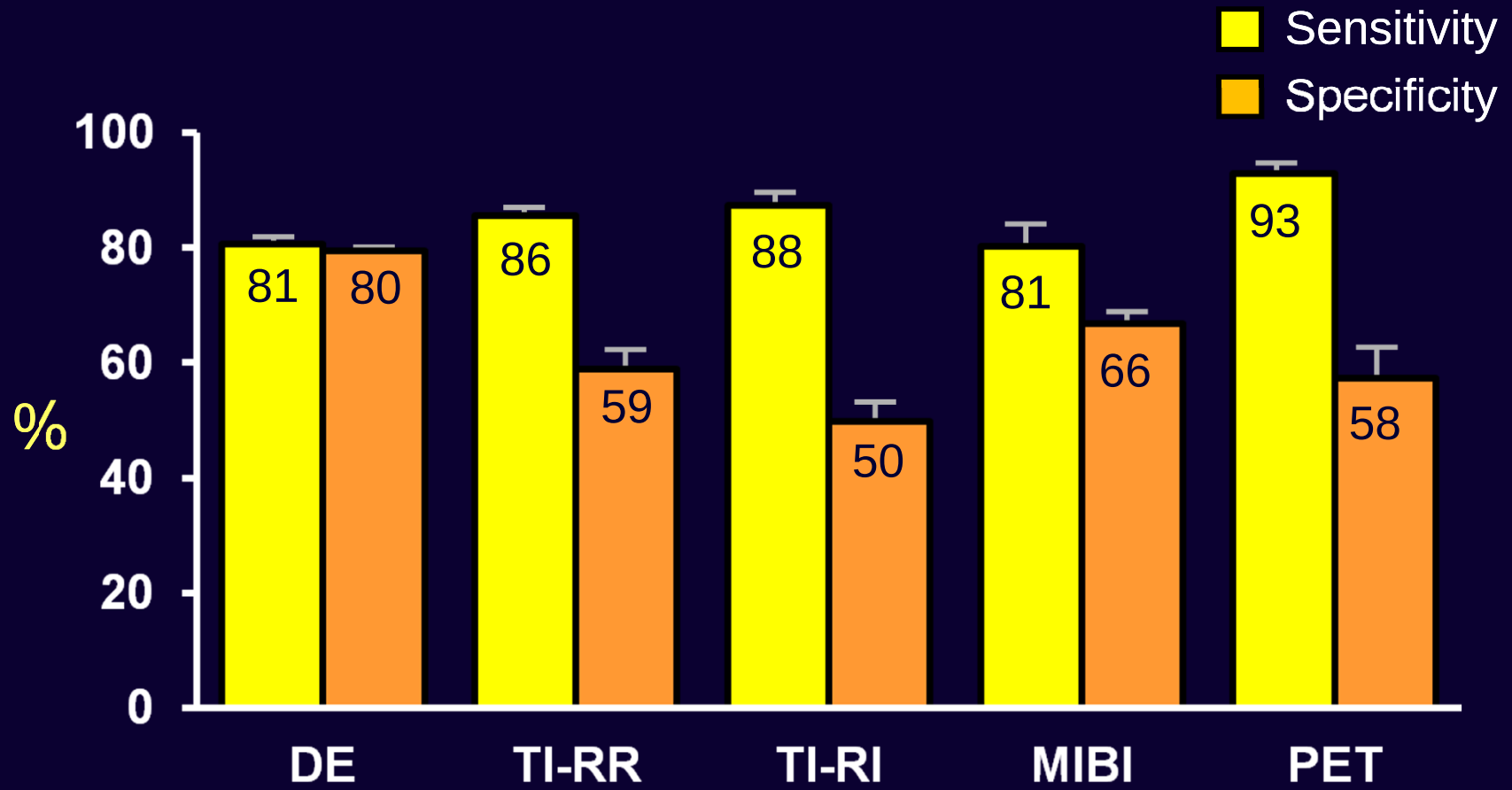
Low Dose



High Dose

Echo vs Nuclear Imaging

Prediction of Contractile Recovery



	DE	TI-RR	TI-RI	MIBI	PET
Studies (no.)	32	22	11	20	20
Patients (no.)	1,090	557	301	488	598

Bax, et al Curr Prob Cardiol, Feb 2001

Vasodilator Stress Pharmacology

- **Dipyridamole**

  Increases endogenous levels of adenosine

- **Adenosine**

  Decreases resistance

Dipyridamole Stress Echo
Protocol I

Infusion of 0.14 mg/kg/min x 4 min (0.56 mg/kg)

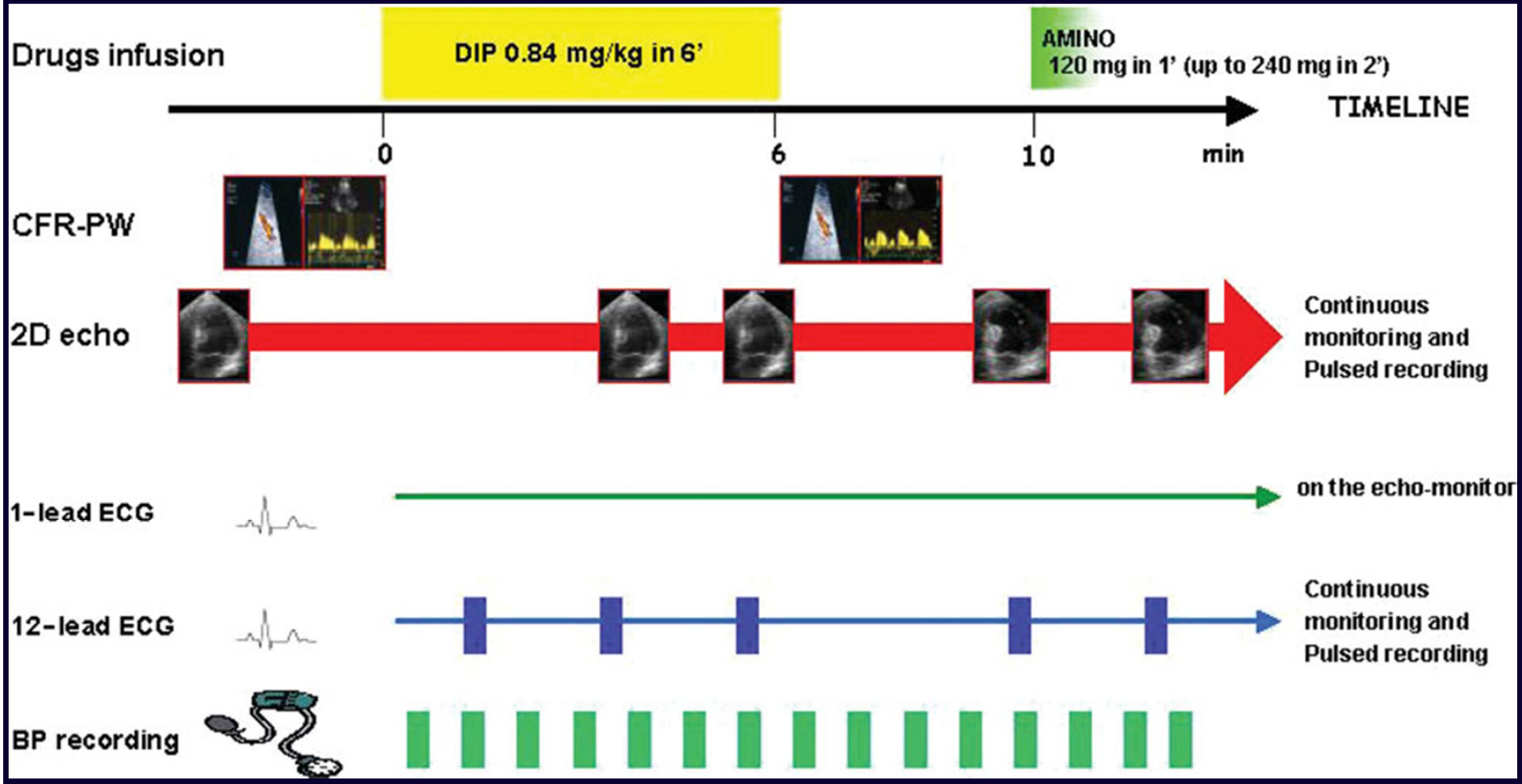
Imaging ➡

if no RWMA for 4 min

- **Additional 0.28 mg/kg x 2 min**
- **Atropine, handgrip exercise**

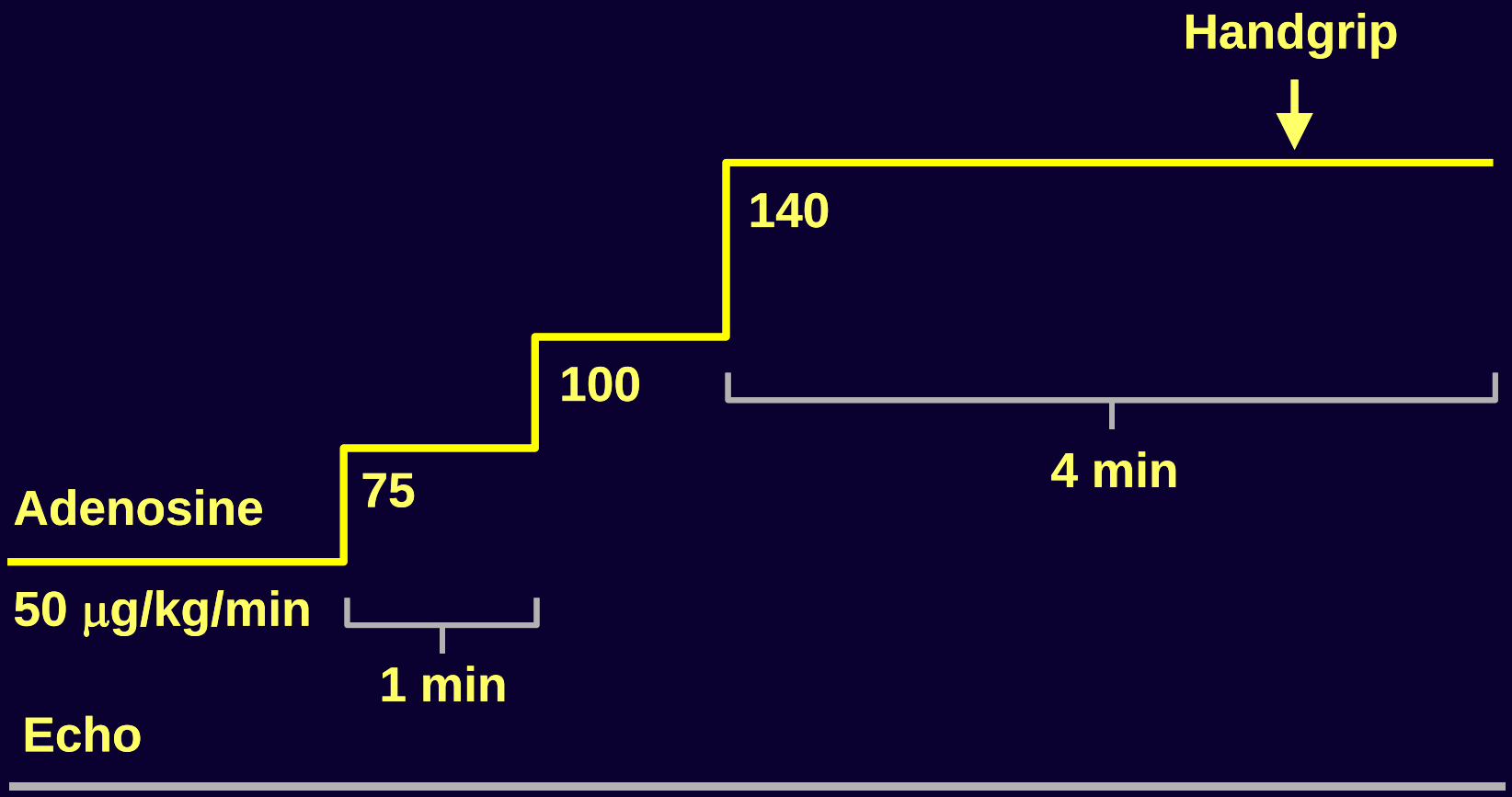
EAE guideline 2008

Dipyridamole Stress Echo
Protocol II



EAE guideline 2008

Adenosine Stress Echo
Protocol



Vasodilator Stress Contraindications

- **Dipyridamole**
  - Hypotension
  - Unstable carotid disease
- **Adenosine or dipyridamole**
  - Severe bronchospasm
  - Heart block: 2nd or 3rd degree

Response for Stress Modalities

	Regional		Global	
Stress method	Normal response	Ischemic response	Normal response	Ischemic response
Treadmill	Postexercise increase in function compared with rest	Postexercise decrease in function compared with rest	Decrease in ESV, increase in EF	Increase in ESV, decrease in EF in multivessel or L main disease
Supine bicycle	Peak exercise increase in function compared with rest	Peak exercise decrease in function compared with rest	Decrease in ESV, increase in EF	Increase in ESV and decrease in EF in multivessel or L main disease
Dobutamine	Increase in function, velocity of contraction compared with rest and usually with low dose	Decrease in function, velocity of contraction compared with low dose; may be less compared with rest	Greater decrease in ESV, marked increase in EF	Often same as normal response; infrequently, ischemia produces decreased EF; cavity dilatation rarely occurs
Vasodilator	Increase in function compared with rest	Decrease in function compared with rest	Decrease in ESV, increase in EF	Often same as normal response; occasionally, ischemia produces decreased EF; cavity dilatation rarely occurs
Atrial pacing	No change or increase in function compared with rest	Decrease in function compared with rest	Decrease in ESV, no change in EF	No change or increase ESV, decrease in EF

Interpretation of Regional Wall Motion

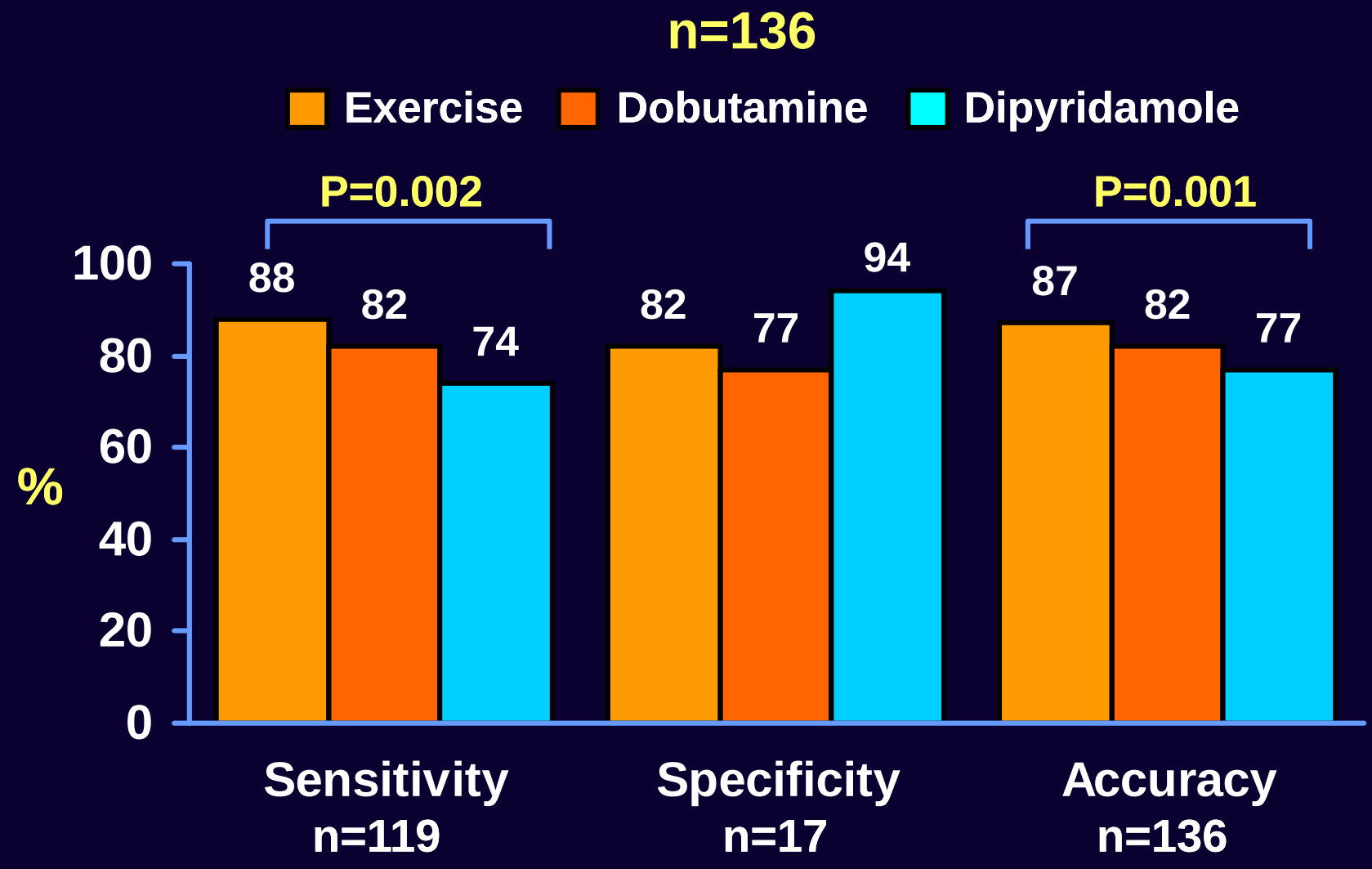
Rest	Stress	Interpretation
Normal	Hyperdynamic	Normal
Normal	New wall motion abnormality	Ischemia
Wall motion abnormality	Worsening	Ischemia
Wall motion abnormality	Unchanged	Infarct
Wall motion abnormality	Biphasic	Viable

Stress Echocardiography
Validation with Coronary Angiography

	No.	Sens	Spec
Treadmill	1,020	88	82
Bike	676	89	83
Dobutamine	1,240	85	83

Pellikka: Prog in CV Dis, 1997

Comparison of Tests in Detecting CAD



Beleslin et al. Circulation, 1994

Dip-stress vs Exe-stress EchoCG for detection of coronary artery disease

	Sensitivity		Specificity		Accuracy		Feasibility	
	DIP	EXE	DIP	EXE	DIP	EXE	DIP	EXE
Picano *et al.*[23]	18/25 (72%)	19/25 (76%)	15/15 (100%)	13/15 (87%)	33/40 (83%)	32/40 (80%)	55/55 (100%)	40/55 (73%)
Deutsch *et al.*[117]	37/51 (73%)	38/51 (75%)	13/15 (87%)	12/15 (80%)	50/66 (76%)	50/66 (76%)	74/80 (95%)	66/80 (84%)
Marangelli *et al.*[52]	15/35 (43%)	31/35 (89%)	23/25 (92%)	22/25 (88%)	38/60 (63%)	53/60 (88%)	80/82 (92%)	84/100 (84%)
Beleslin *et al.*[51]	88/119 (74%)	105/119 (88%)	16/17 (94%)	14/17 (82%)	105/136 (77%)	118/136 (87%)		
Dagianti *et al.*[64]	13/25 (52%)	19/25 (76%)	34/35 (97%)	33/35 (94%)	47/60 (78%)	52/60 (87%)	60/60 (100%)	57/60 (95%)
Bjornstad *et al.*[59]	21/31 (68%)	26/31 (84%)	6/6 (100%)	4/6 (67%)	27/37 (73%)	30/37 (81%)		
Schroder *et al.*[95]	50/65 (77%)	35/65 (53%)	8/9 (89%)	8/9 (89%)	58/74 (78%)	43/74 (58%)	119/121 (98%)	74/83 (89%)
Loimaala *et al.*[118]	41/44 (93%)	40/44 (91%)	12/16 (75%)	7/16 (44%)	53/60 (88%)	47/60 (78%)		
Total	283/395(72%)	313/395 (79%)	127/138 (92%)	113/138 (82%)	411/533 (77%)	425/533 (80%)	388/398 (97%)	321/398 (81%)

EAE guideline 2008

Dip-stress vs Dob-stress EchoCG for detection of coronary artery disease

	Sn (%), *n*		Sp (%), *n*		Acc (%), *n*	
	Dip	Dop	Dip	Dop	Dip	Dop
Salustri *et al.*[70]	82, 23/28	79, 22/28	89, 16/18	78, 14/18	85, 39/46	72, 36/46
Pingitore *et al.*[34]	82, 75/92	84, 77/92	94, 17/18	89, 15/18	84, 92/110	84, 92/110
San Roman *et al.*[115]	81, 54/66	78, 52/66	94, 34/36	88, 32/36	86, 88/102	82, 82/102
Loimaala *et al.*[118]	93, 41/44	95, 42/44	75, 12/16	63, 10/16	87, 53/60	88, 52/60
Nedeljcovic *et al.*[119]	96, 66/69	93, 64/69	92, 44/48	92, 44/48	91, 107/117	94, 110/117
Total	87, 259/299	86, 257/299	90, 123/136	84, 115/136	87, 379/435	85, 372/435

EAE guideline 2008

Esophageal Pacing Stress Echo

Protocol

1. Small esophageal lead placed
2. Begin pacing 10 beats/min above baseline
3. Increase pacing 20 beats/min every 2 min until 85% HR reached or other endpoints

Lee et al JACC,1999

Esophageal Pacing Stress Echo

Advantages

- Fast protocol
- Reach target HR
- Continuous imaging
- Avoid arrhythmias
- Avoid HTN response

Disadvantages

- Esophageal intubation
- Rare sedation needed
- IV start
- BP response variable
- Atropine +/-

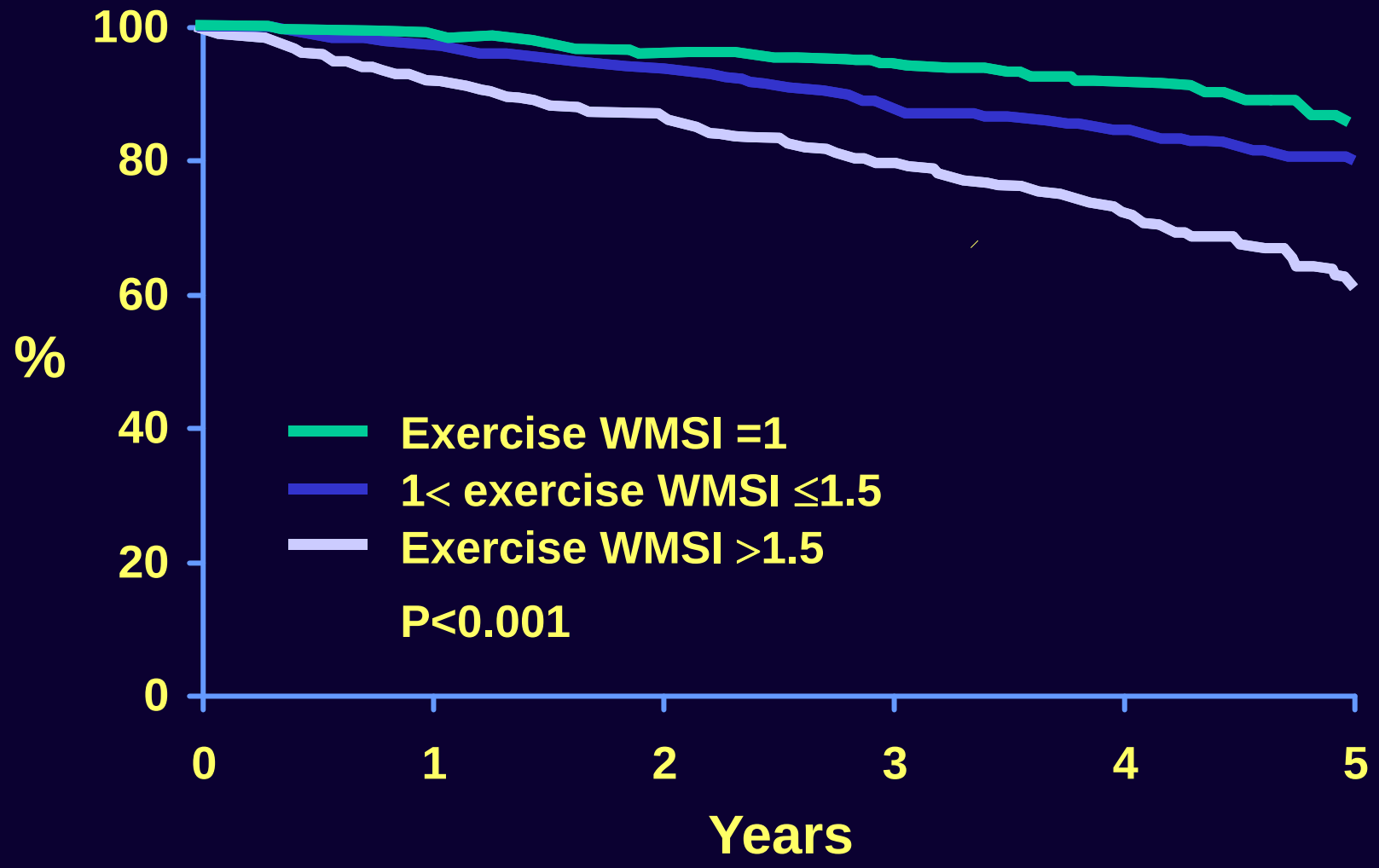
Stress Echocardiography
Prognostic Value

- Role of stress echo in predicting cardiac events has been documented in >40 studies in >10,000 patients
- Positive study identifies patients at risk of events during follow-up
- Normal study predicts a good outcome

Normal Exercise Echo
Overall Survival in 1,325 Patients

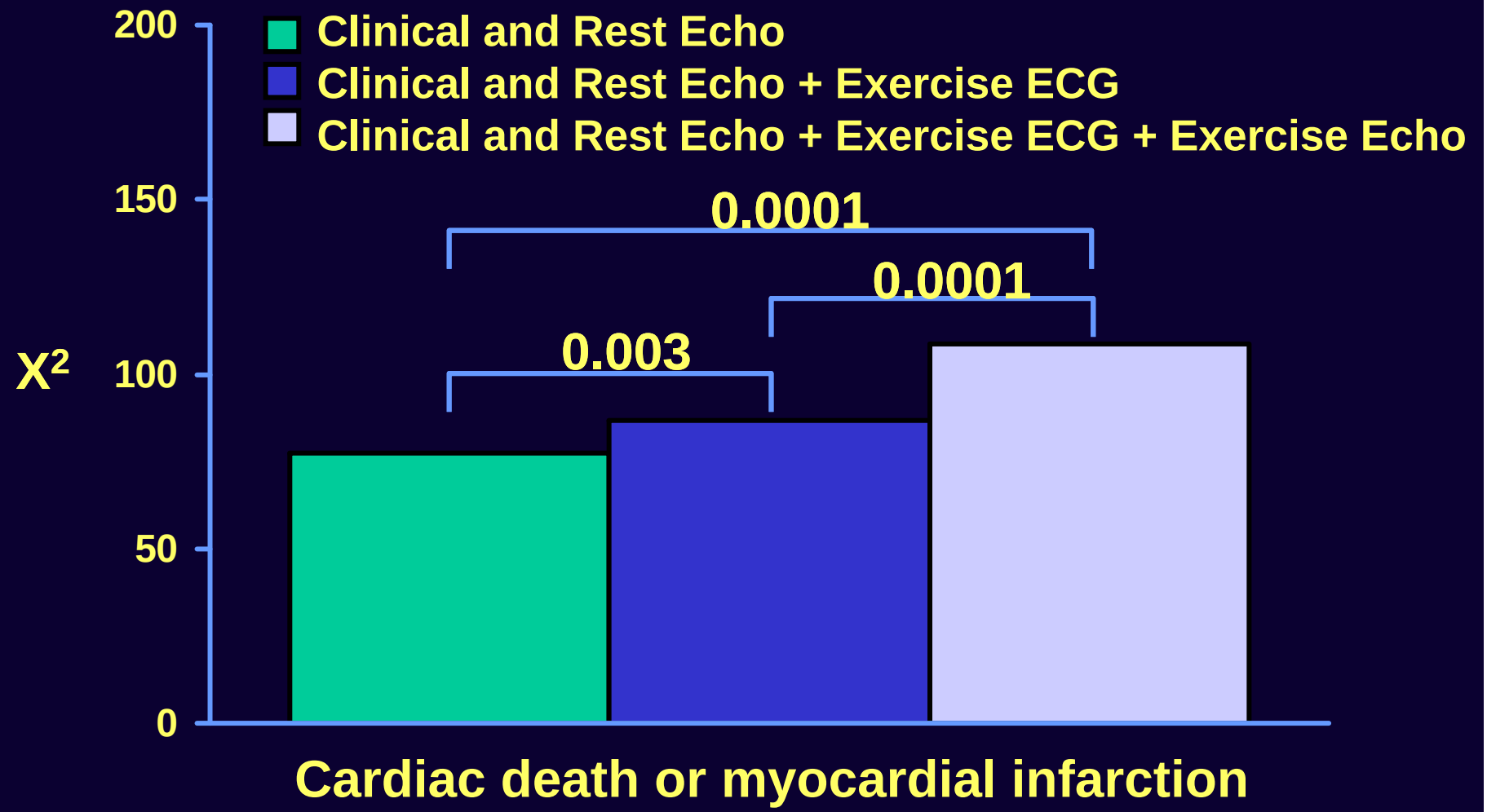
McCully et al: JACC, 1998

Effect of Exercise WMSI on Survival Free of All Cardiac Events in 2,632 Patients > 65 years



Arruda et al: JACC, 2001

Incremental Value of Exercise Echocardiography in 2,632 Patients ≥65 years



Arruda et al: JACC, 2001

Conclusion

- Various stress echo modalities significantly improve the diagnostic and prognostic power in the evaluation of patients with CAD.
- The choice of imaging modality in a particular setting depends on several factors including availability, feasibility, experience and cost considerations.