

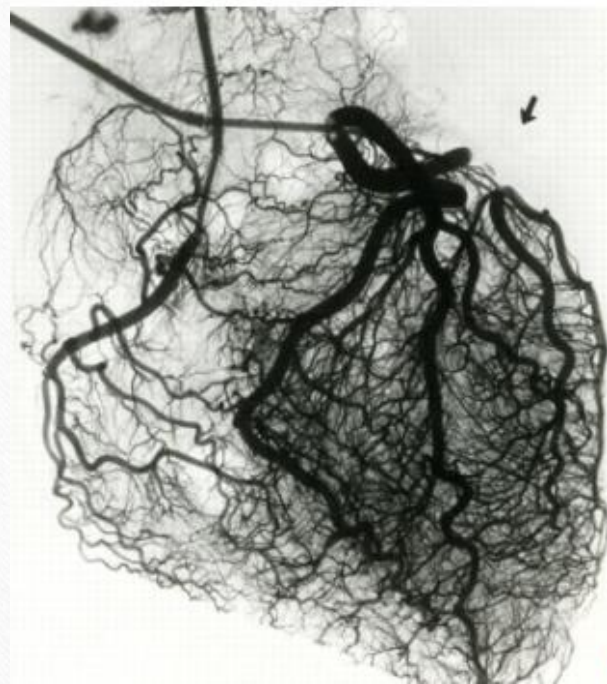
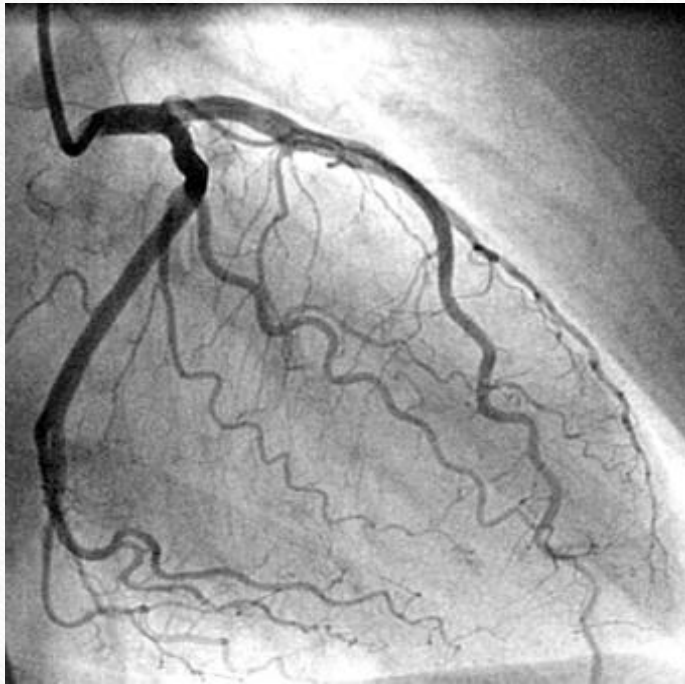
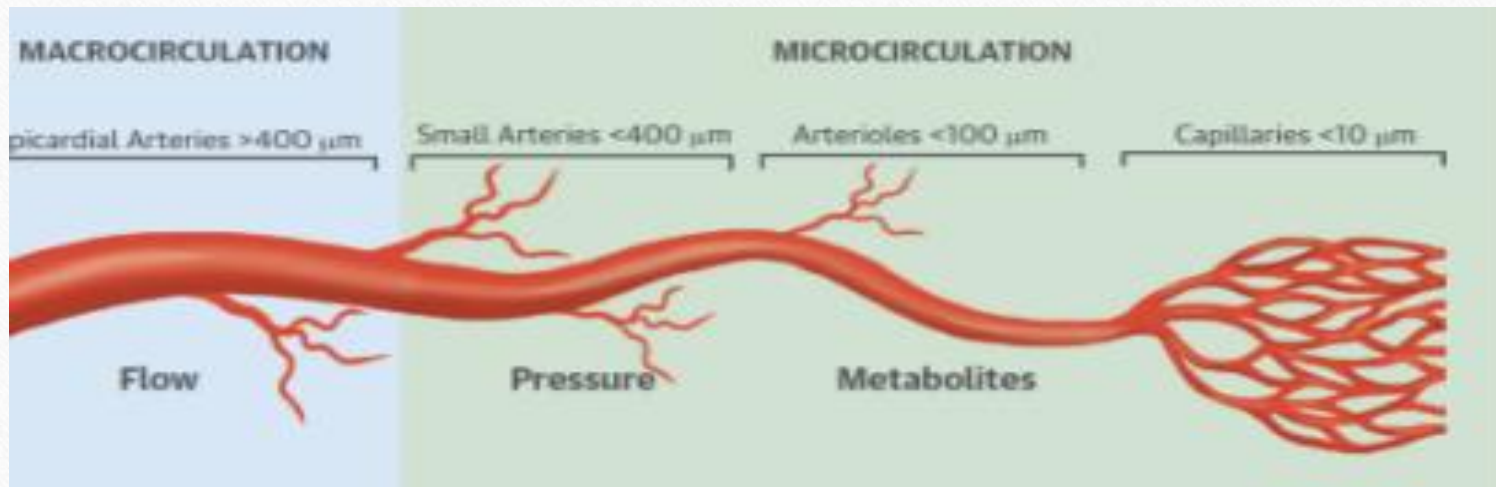
Μή επεμβατικές μέθοδοι διάγνωσης και σταδιοποίησης στεφανιαίας νόσου

ΓΙΜΣ: ΚΑΡΔΙΟΜΕΤΑΒΟΛΙΚΗ ΙΑΤΡΙΚΗ

Ζήσιμος Κωνσταντίνος, Καρδιολόγος

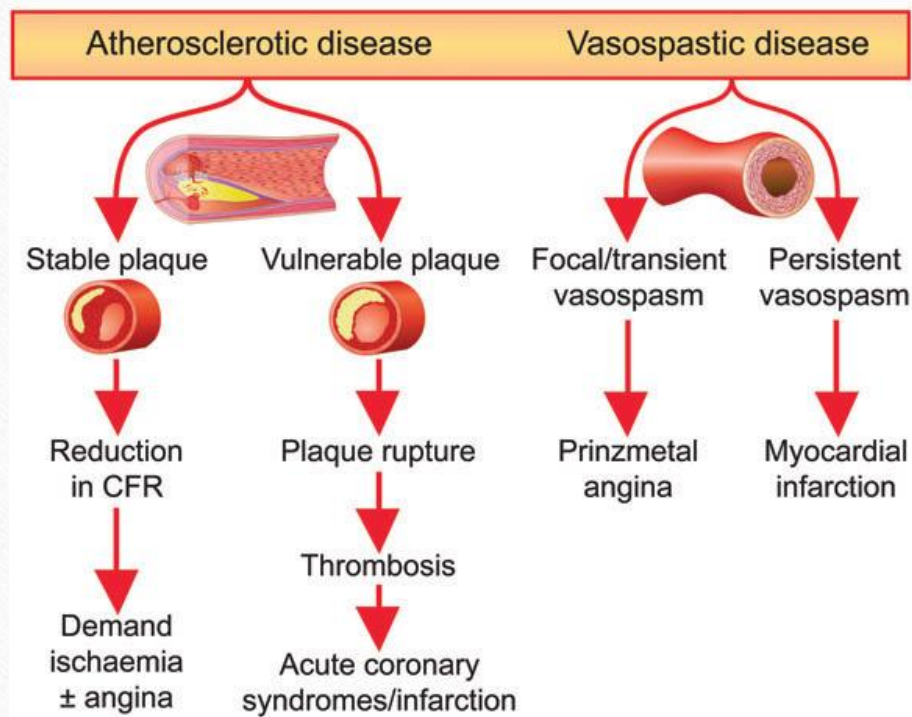
Functional Tests

- Treadmill test
- Stress echo
- SPECT
- Stress MRI

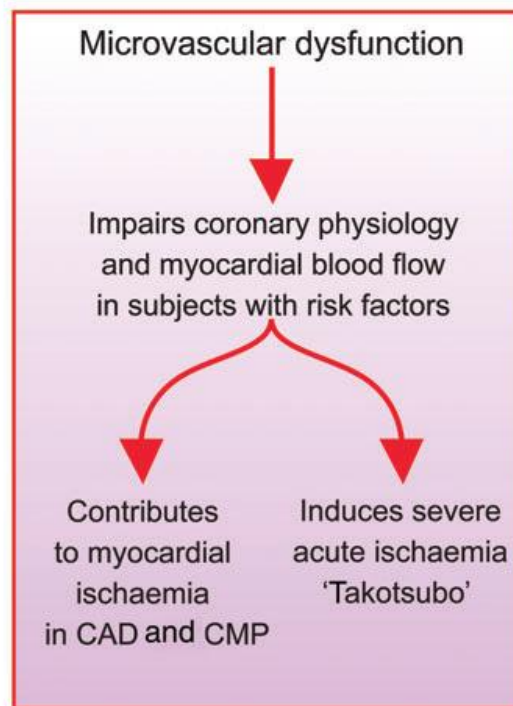


Mechanisms of myocardial ischaemia

Epicardial coronary arteries

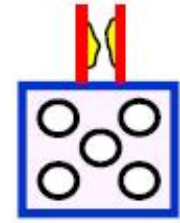


Coronary microcirculation

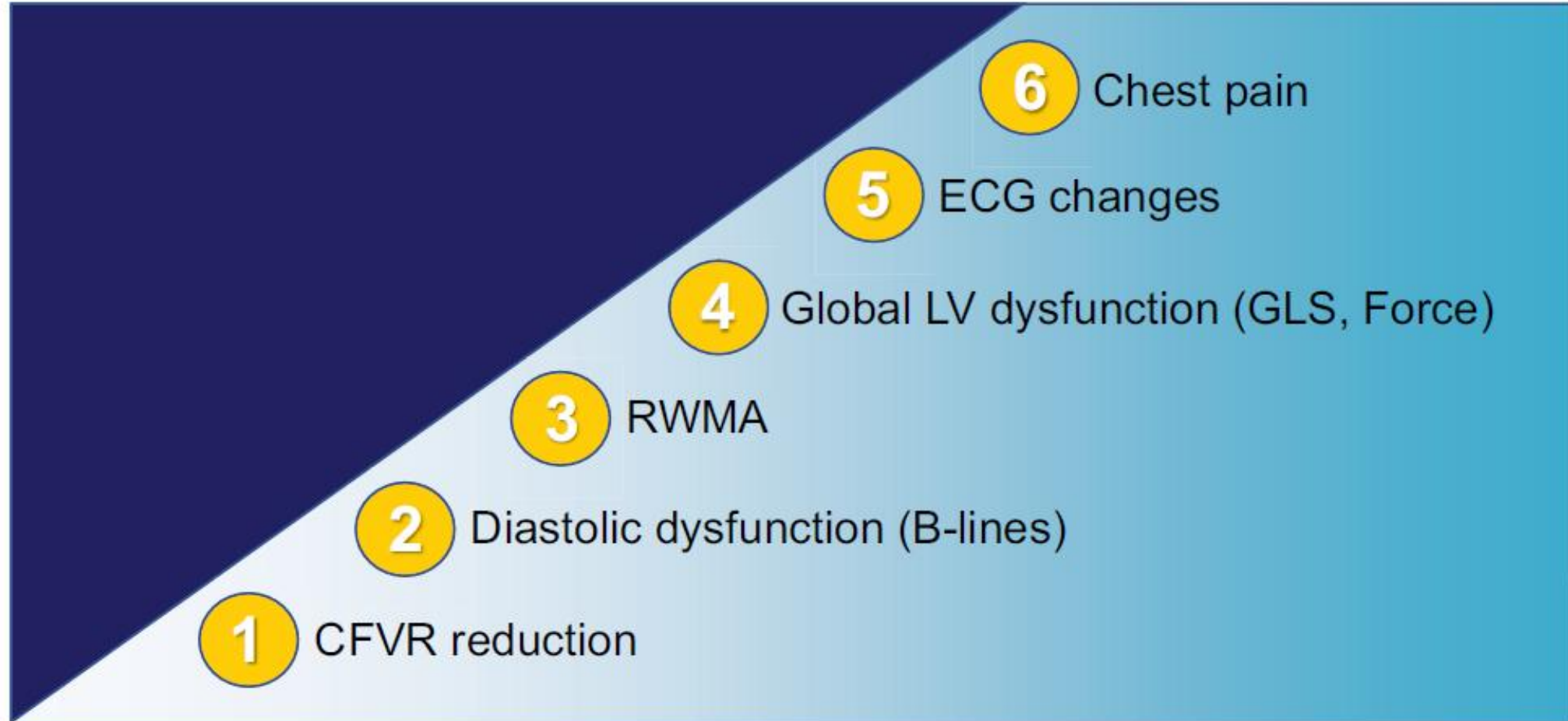


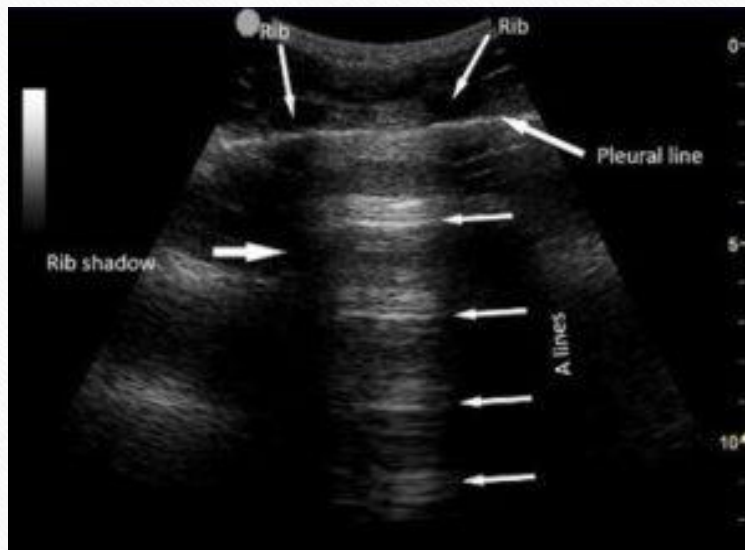
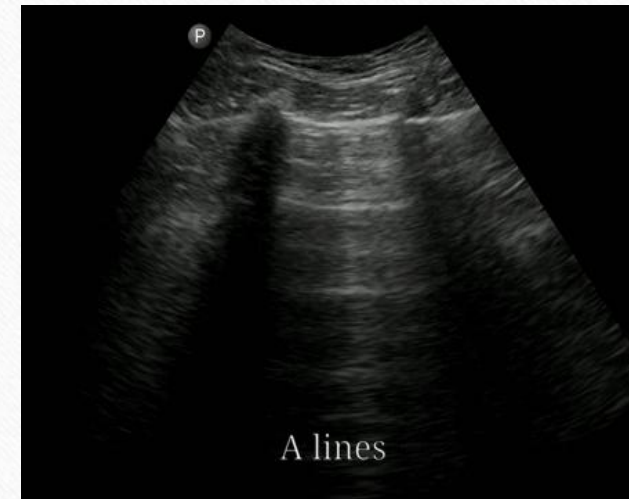
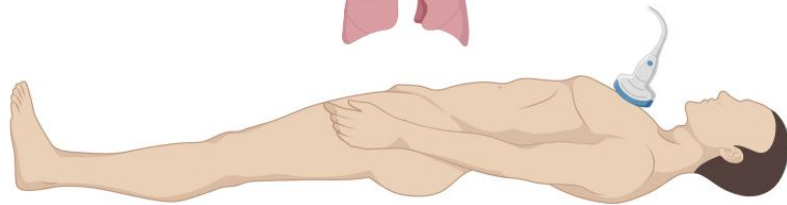
These three mechanisms can overlap

Ischemic cascade in epicardial Coronary Artery Disease

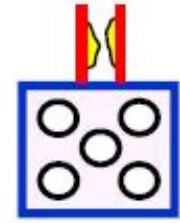


Temporal sequence of ischemic events

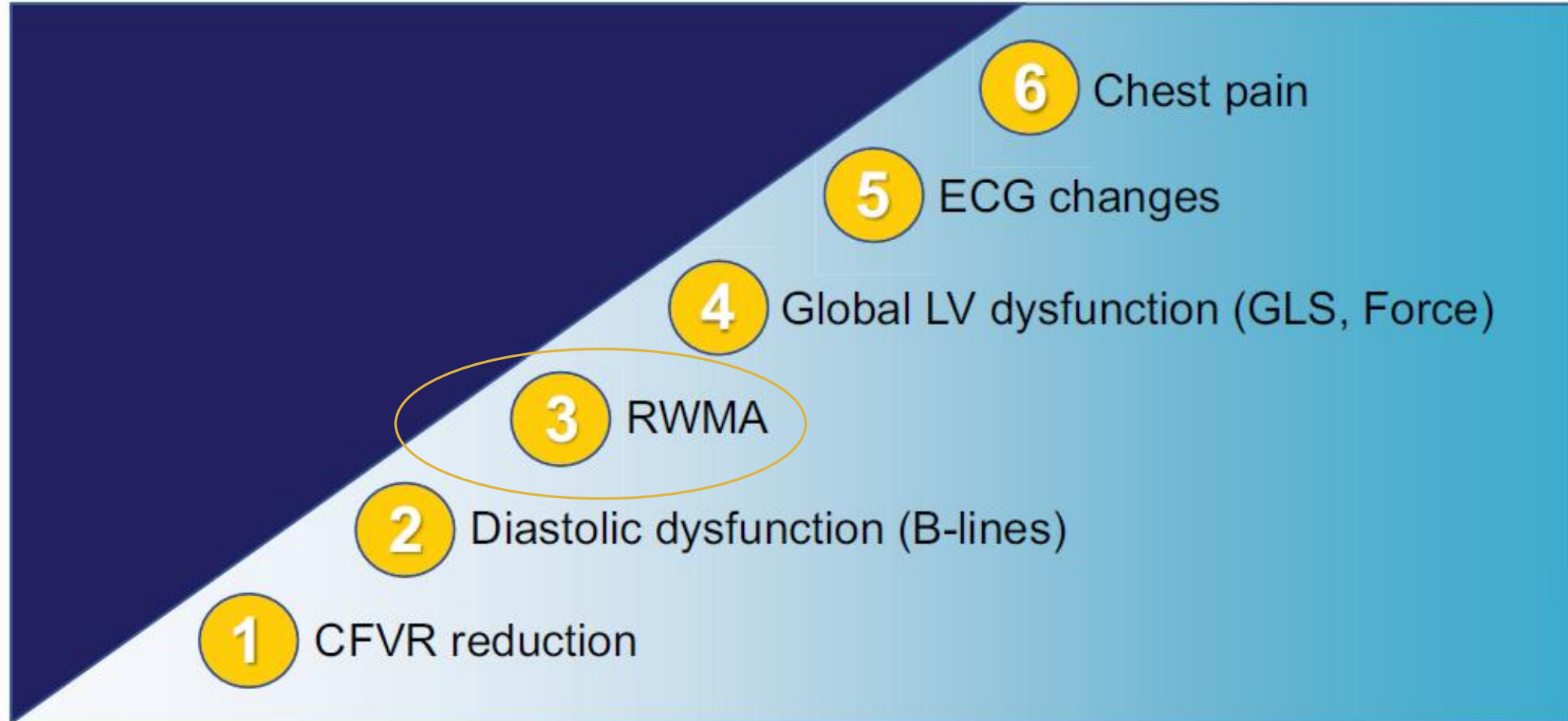




Ischemic cascade in epicardial Coronary Artery Disease



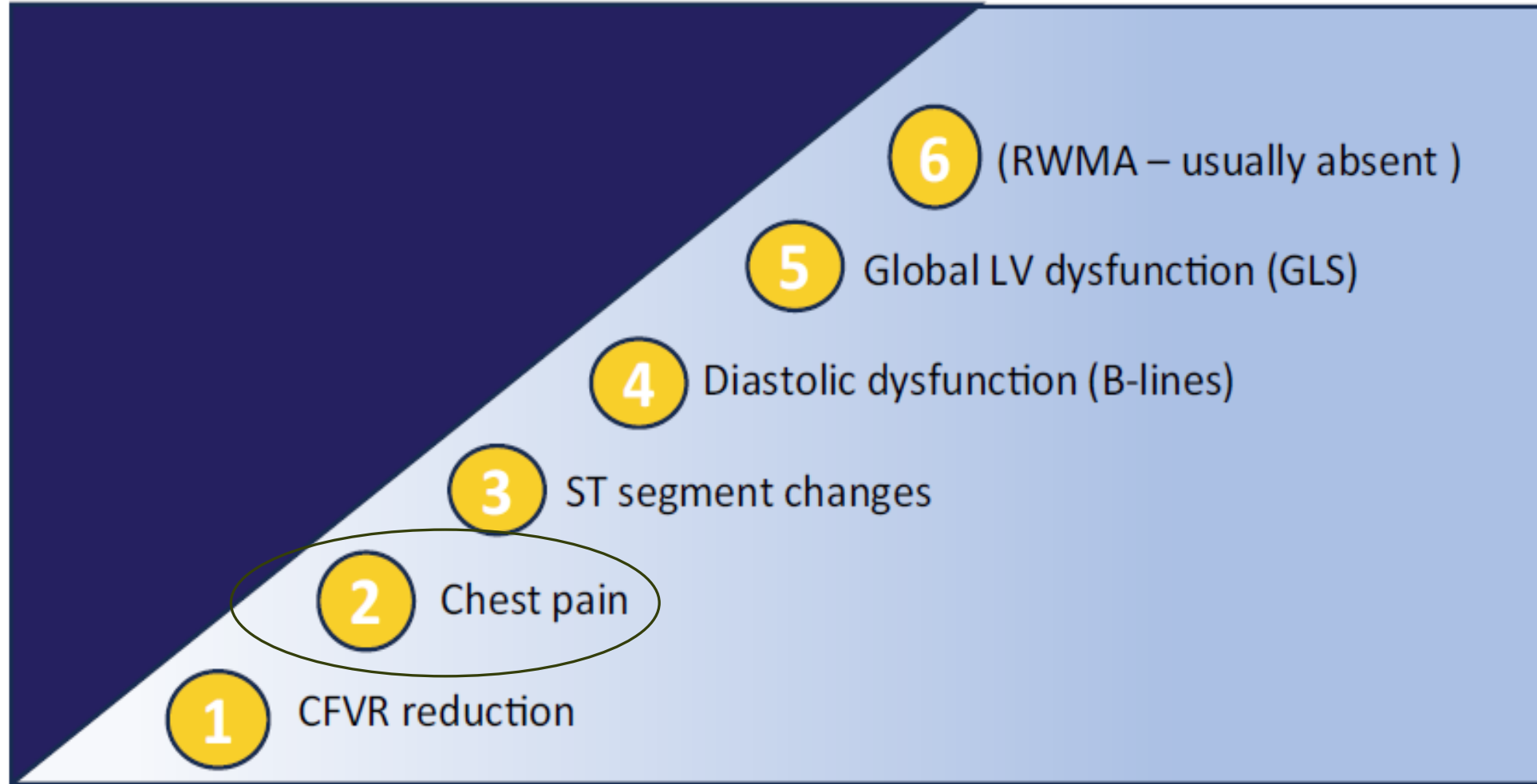
Temporal sequence of ischemic events



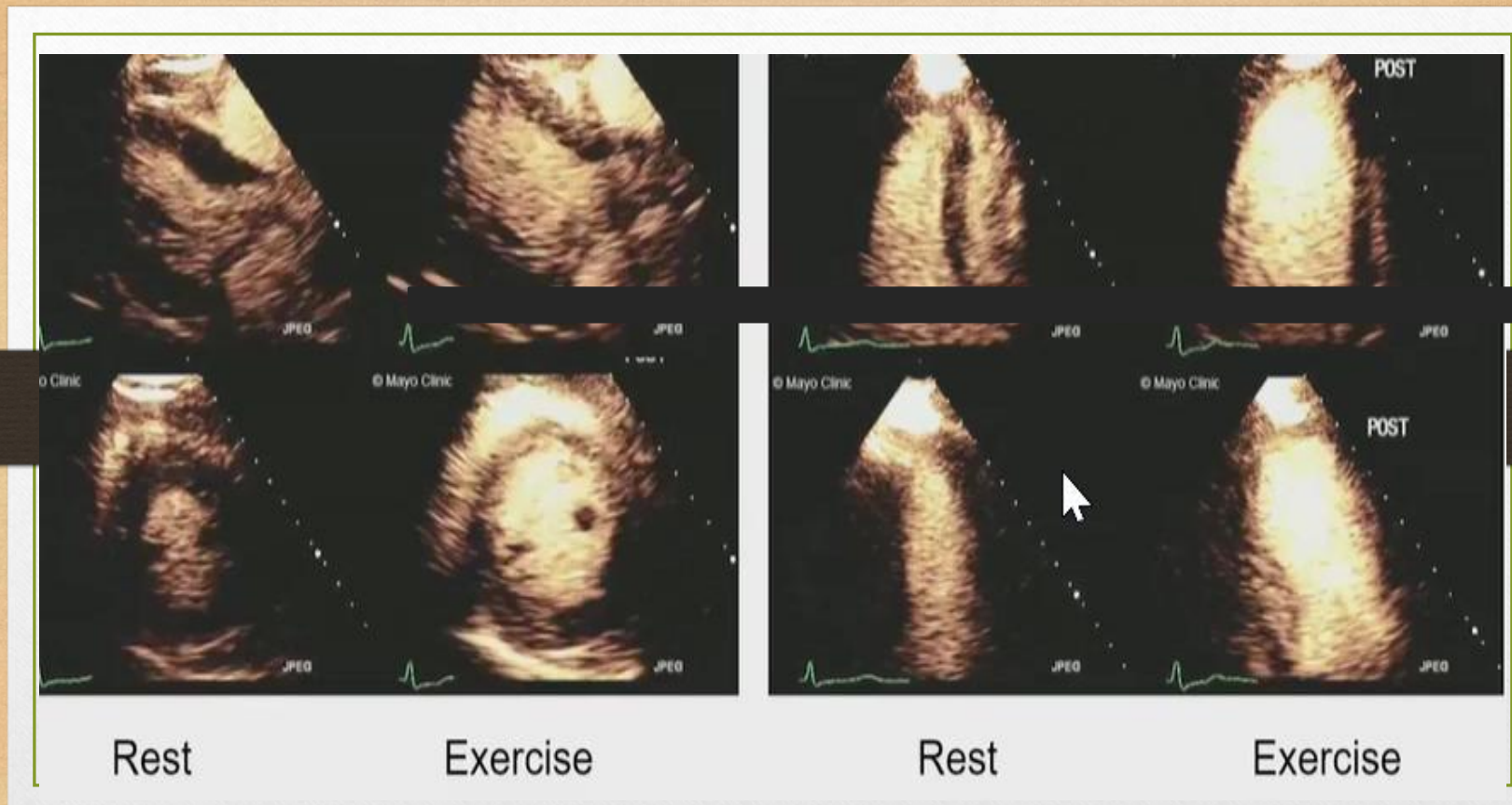
Ischemic cascade in coronary microvascular disease



Temporal sequence of ischemic events



75woman, exertional dyspnea-chest pain, normal coronary arteries



3 years later



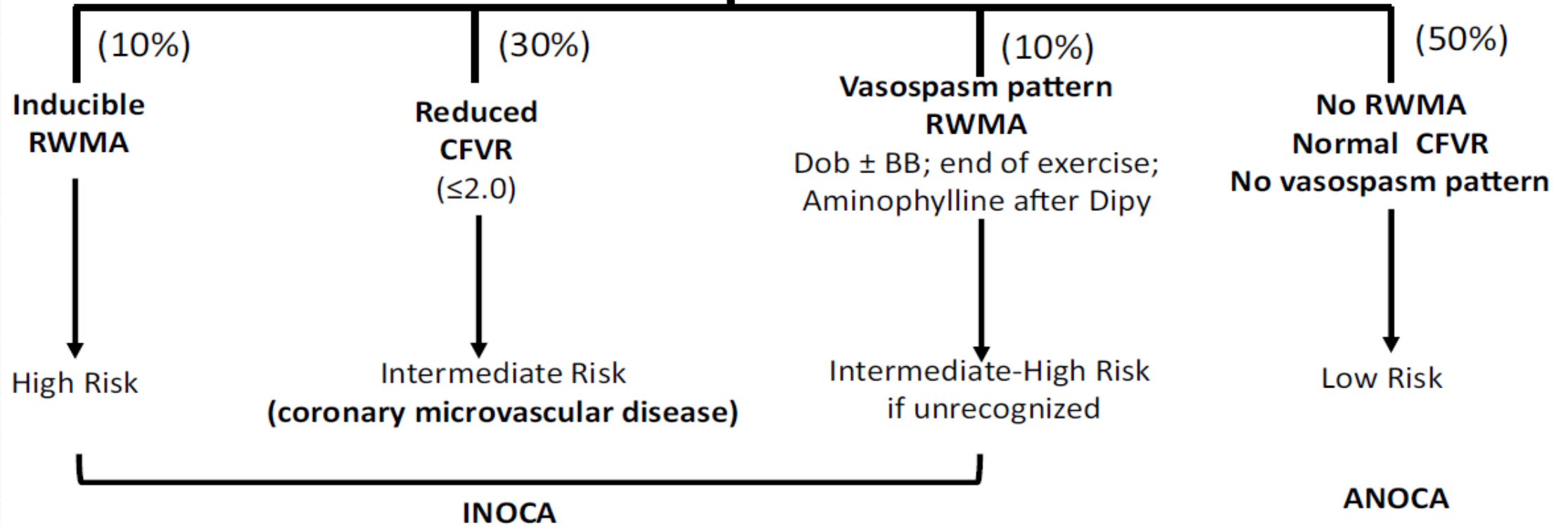
Are Some False-Positive Stress Echocardiograms a Forme Fruste Variety of Apical Ballooning Syndrome?

Aaron M. From, MD, Abhiram Prasad, MD*, Patricia A. Pellikka, MD, and Robert B. McCully, MBChB

The mechanisms for abnormal stress echocardiograms (SEs) in patients with normal coronary arteries have not been clearly elucidated. We hypothesized that in some patients, this phenomenon may represent a forme fruste of apical ballooning syndrome (ABS). The aim of the study was to evaluate the characteristics of patients with strongly false-positive SEs and determine whether there were similarities to ABS. Thirty-one patients from the Mayo Clinic stress echocardiography database who had normal function at rest, extensive regional wall motion abnormalities in association with an abnormal response of left ventricular end-systolic cavity size at peak stress, and angiographically normal coronary arteries were evaluated. Eighty-four percent were women with a mean age of 61 ± 12 years, 6% had a positive stress electrocardiogram, and only 26% had a hypertensive response to stress. In 81%, left ventricular ejection fraction decreased with stress and 97% developed new regional wall motion abnormalities in ≥ 4 segments. Peak wall motion score index was 1.65 ± 0.39 . Midventricular (100%) and apical (87%) segments were most often involved with relative sparing of the basal segments (77%; $p = 0.01$). There were no deaths during follow-up (2.3 ± 0.7 years). In conclusion, the major findings of this study were that strongly false-positive SEs occurred predominantly in postmenopausal women, and frequently involved the apical and mid-left ventricular segments, features that were similar to ABS. Data were consistent with the hypothesis that some false-positive SEs may represent a forme fruste of ABS. © 2009 Elsevier Inc. (Am J Cardiol 2009;103:1434–1438)

ANOCA

SE



Main indications of Stress Echo for ischemia

- In individuals with suspected CCS and moderate or high (>15%–85%) pre-test likelihood of obstructive CAD
- Stress imaging should be considered before high-risk NCS in asymptomatic patients with poor functional capacity, and previous PCI or CABG.
- Intermediate coronary artery lesions
- Follow-up : >2 years after PCI , >5 years after CABG)
- Viability ?

Contraindications

absolute

- *STEMI,NSTEMI*
-
- *Sustained Ventricular Tachy*
 - *Recent thrombus in LV*
 - *Acute conditions (inflammation, stroke, ech*

END POINTS (diagnostic or non-diagnostic)

- *Achievement of target HR (85% or 90% of maximal, age-predicted HR)*
 - *Completion of protocol (maximal drug dose-maximal workload)*
 - *Obvious echocardiographic findings of extensive myocardial ischemia*
 - *LV dilatation*
 - *SBP >220 mmHg or DBP > 110 mmHg, symptomatic drop in SBP*
 - *New arrhythmias (sustain VT, sustain SVT, AF, brady<40bpm)*
 - *Limiting symptoms (chest pain, fatigue)*
 - *Central nervous system symptoms (ataxia, pre-syncope, headache)*
- Diagnostic
- Non-diagnostic

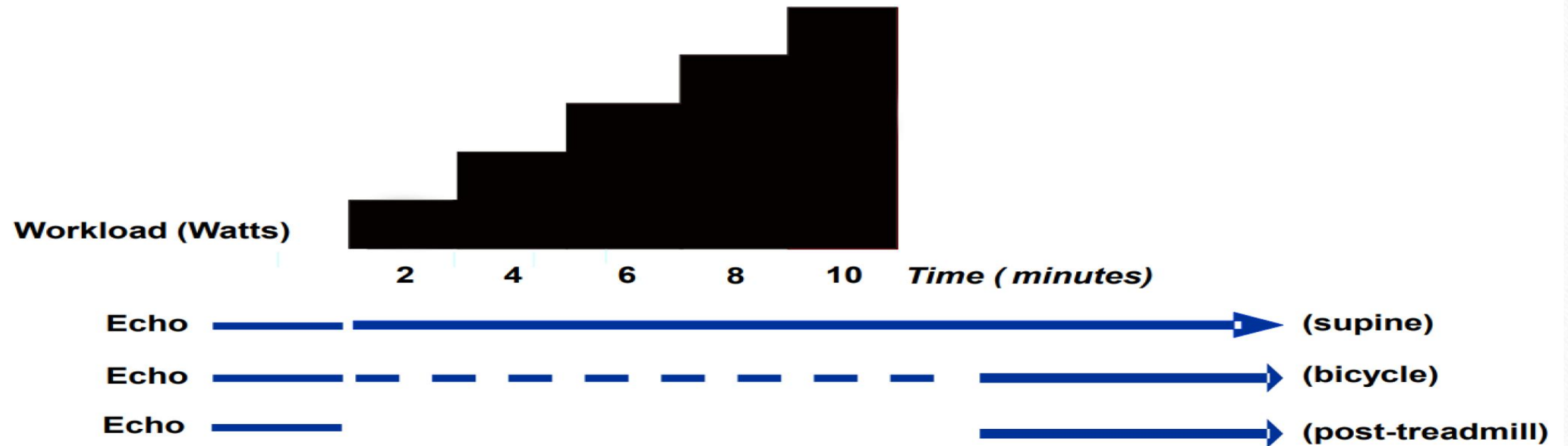
Bicycle



Treadmill



Supine



Exercise is the only truly physiological test and by far the safest

Low exercise capacity, poor HR recovery, and failure to reach target HR are more important predictors of outcome than ST changes

- Exercise is a well validated independent prognostic factor ¹
- Poor exercise capacity (< 5METS) identifies a high risk population
- Achieving ≥ 10 METS: Medical therapy as good as CABG no matter how bad the CAD ²
- 13 METS = Excellent prognosis, regardless of exercise response

1. Myers J, Prakash M, Froelicher V, Do D, Partington S, Atwood JE. Exercise capacity and mortality among men referred for exercise testing. *N. Engl. J. Med.* Mar 14 2002;346(11):793-801.

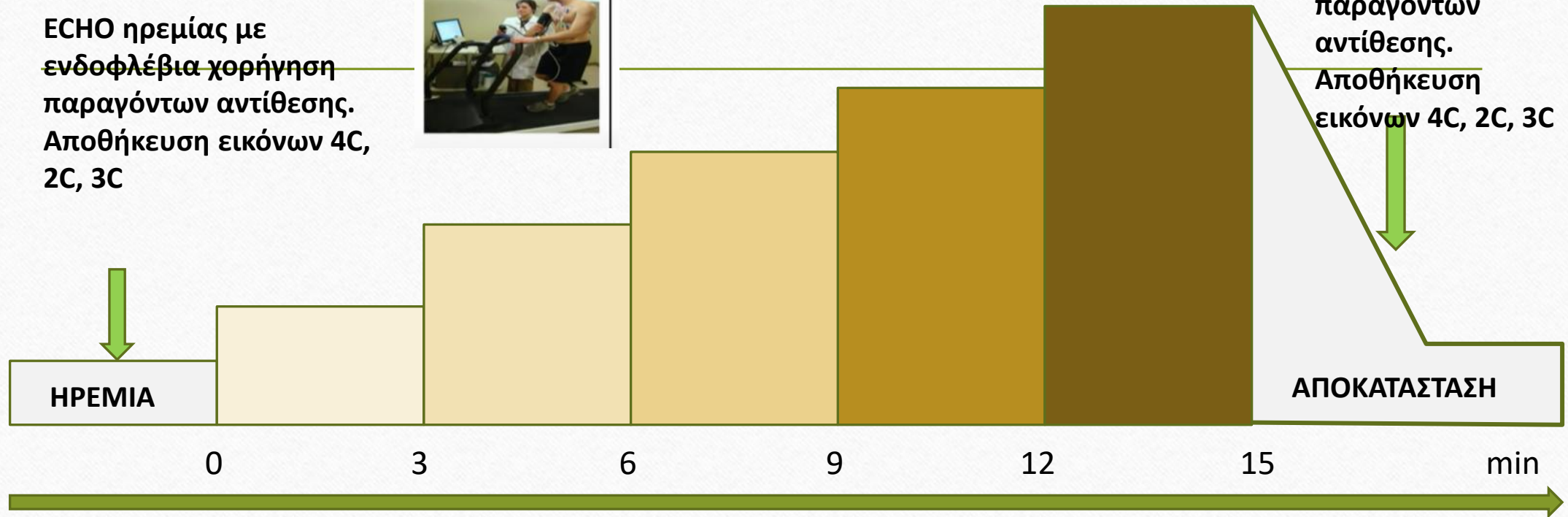
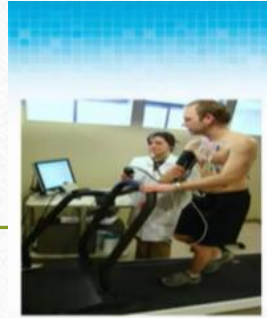
2. Weiner, D. A., Ryan, T. J., McCabe, C. H., Chaitman, B. R., Sheffield, L. T., Fisher, L. D., et al. (1986). The role of exercise testing in identifying patients with improved survival after coronary artery bypass surgery. *Journal of the American College of Cardiology*, 8(4), 741-748

SE PROTOCOLS

STRESS ECHO ΜΕ ΑΣΚΗΣΗ (ΔΙΑΔΡΟΜΟΣ)

Στόχος HR =
 $0,9 * (220 - \text{age})$

ECHO ηρεμίας με
ενδοφλέβια χορήγηση
παραγόντων αντίθεσης.
Αποθήκευση εικόνων 4C,
2C, 3C



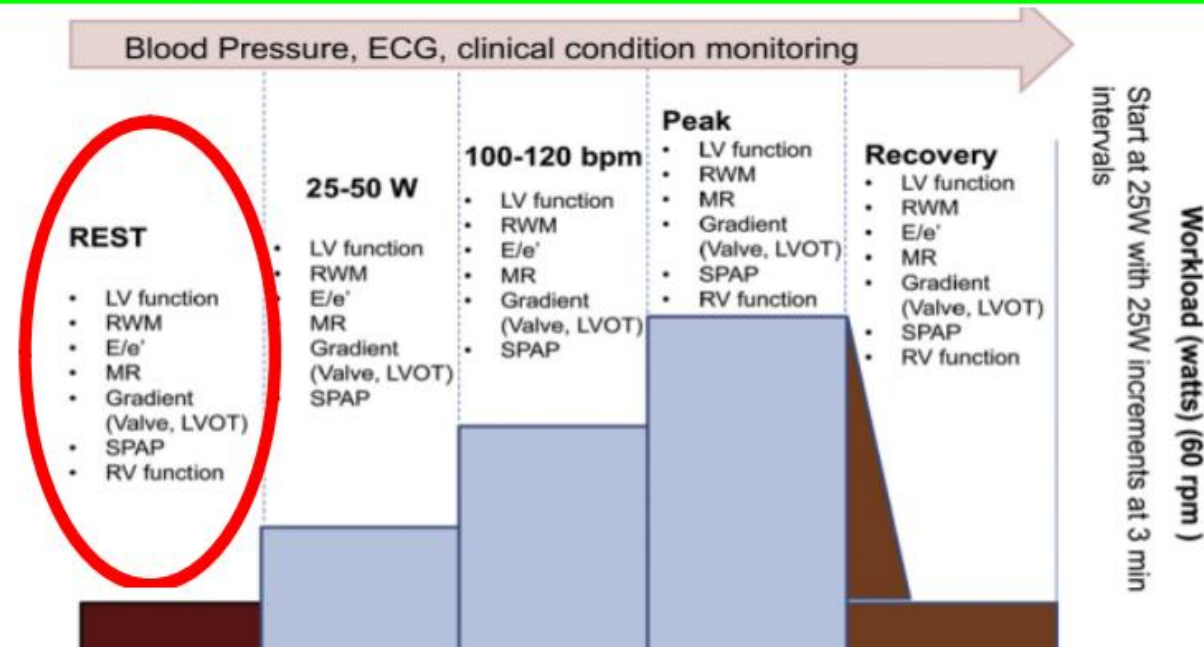
ECHO στο πρώτο
λεπτό της
αποκατάστασης με
ενδοφλέβια
χορήγηση
παραγόντων
αντίθεσης.
Αποθήκευση
εικόνων 4C, 2C, 3C

Συνεχής κλινική εκτίμηση και καταγραφή αρτηριακής πίεσης, ΗΚΓ (Χρήση πρωτοκόλλου του Bruce).

Stress echo με ποδήλατο

Exercise echocardiography Protocol: Parameters that should be assessed at each stage

The patient pedals against an increasing workload at a constant cadence



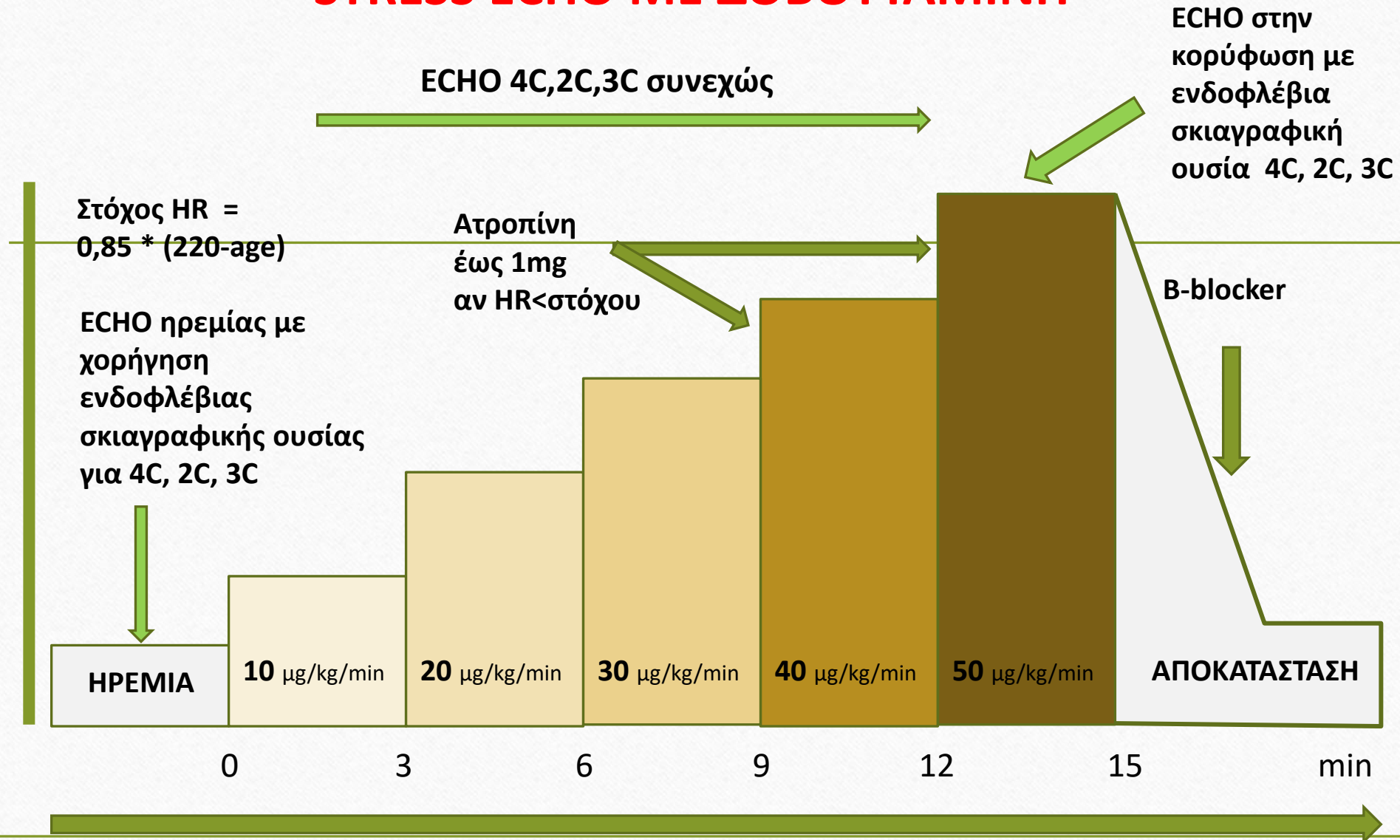
Pharmacological Stress Echo

Unfortunately

- ✓ not all the patients are capable of maximally exercise (e.g. those with intermittent claudication)
- ✓ someone exercises submaximally
- ✓ someone has an uninterpretable ECG

SE PROTOCOLS

STRESS ECHO ME ΔΟΒΟΥΤΑΜΙΝΗ



Συνεχής κλινική εκτίμηση και καταγραφή αρτηριακής πίεσης, ΗΚΓ.

ΔΟΒΟΥΤΑΜΙΝΗ

- *Συνθετική κατεχολαμίνη*
 - *β1 ινóτροπη και χρονóτροπη δράση*
-
- *Έναρξη δράσης σε 1-2 λεπτά*
 - *Χρόνος ημίσειας ζωής 2 λεπτά*
 - *Ήπιες παρενέργειες: αιμωδίες τριχωτού κεφαλής, εξάψεις, επιθυμία για ούρηση, αίσθημα παλμών*
 - *Σοβαρές παρενέργειες: Σύμπλοκη κοιλιακή εκτοπία, ναυτία ή/και κεφαλαλγία, υπόταση / βραδυκαρδία, υπερκοιλιακές αρρυθμίες, υπέρταση*

ΧΡΗΣΗ ΑΤΡΟΠΙΝΗΣ

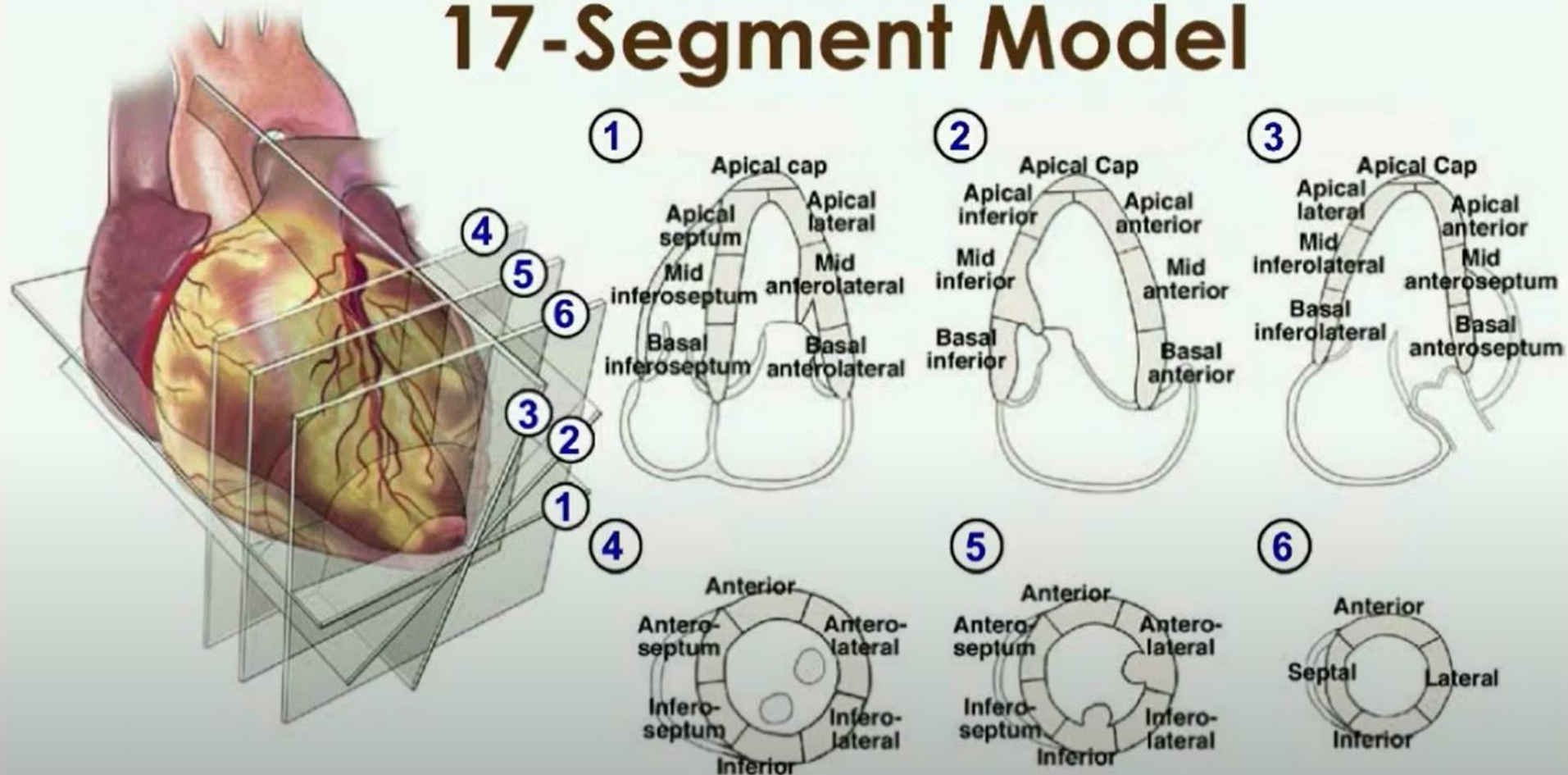
Αντιχολινεργικό, αύξηση καρδιακής συχνότητας

Αύξηση ευαισθησίας σε λήψη β-αναστολέων και νόσο 1 αγγείου

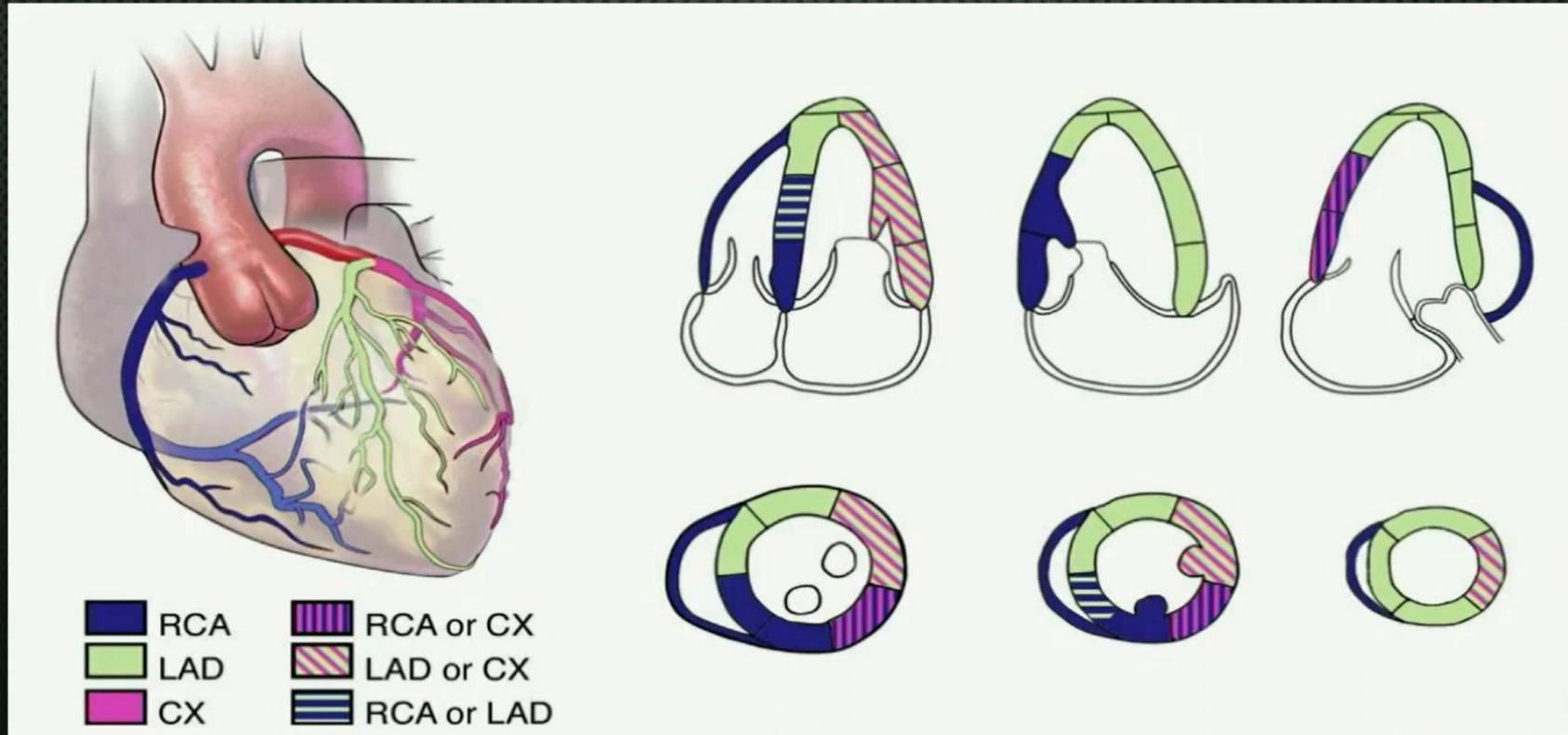
Προσοχή σε γλαύκωμα και σοβαρή υπερτροφία προστάτη

Πρώιμη χορήγηση μειώνει το χρόνο της εξέτασης και τη συνολική δόση δοβουταμίνης

17-Segment Model

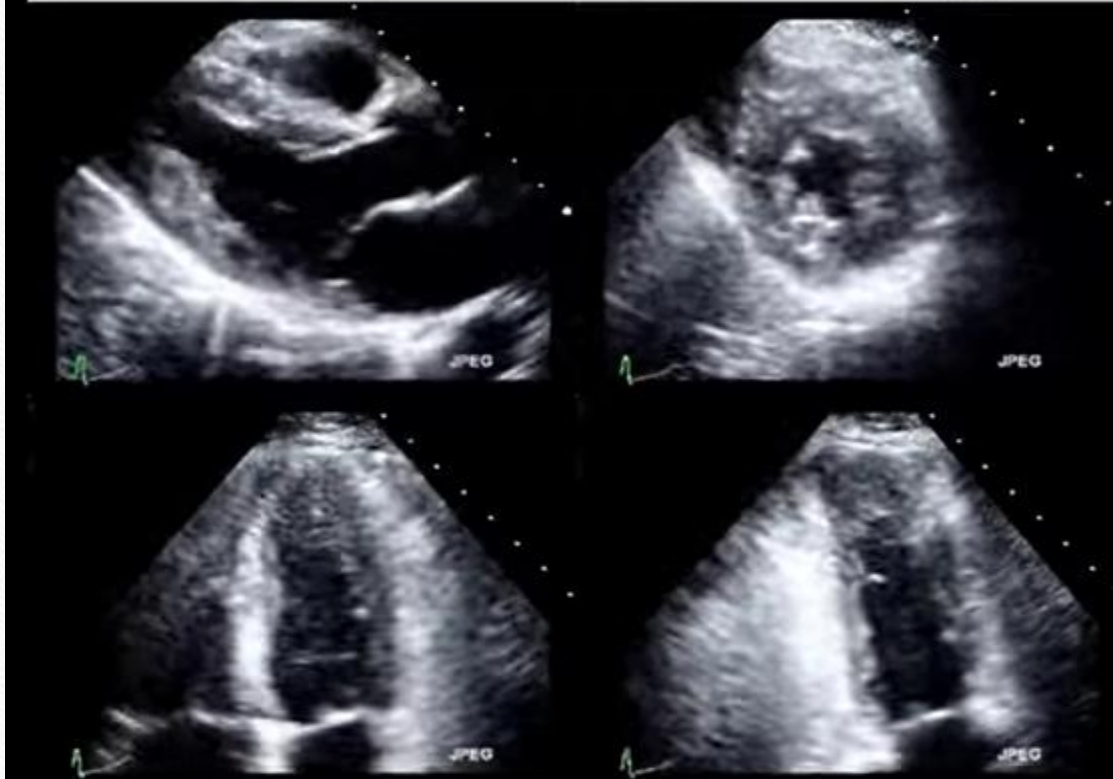


KNOW YOUR PERFUSION DISTRIBUTION



Lang RM, et al. *J Am Soc Echocardiol* (2015) 28:1-39

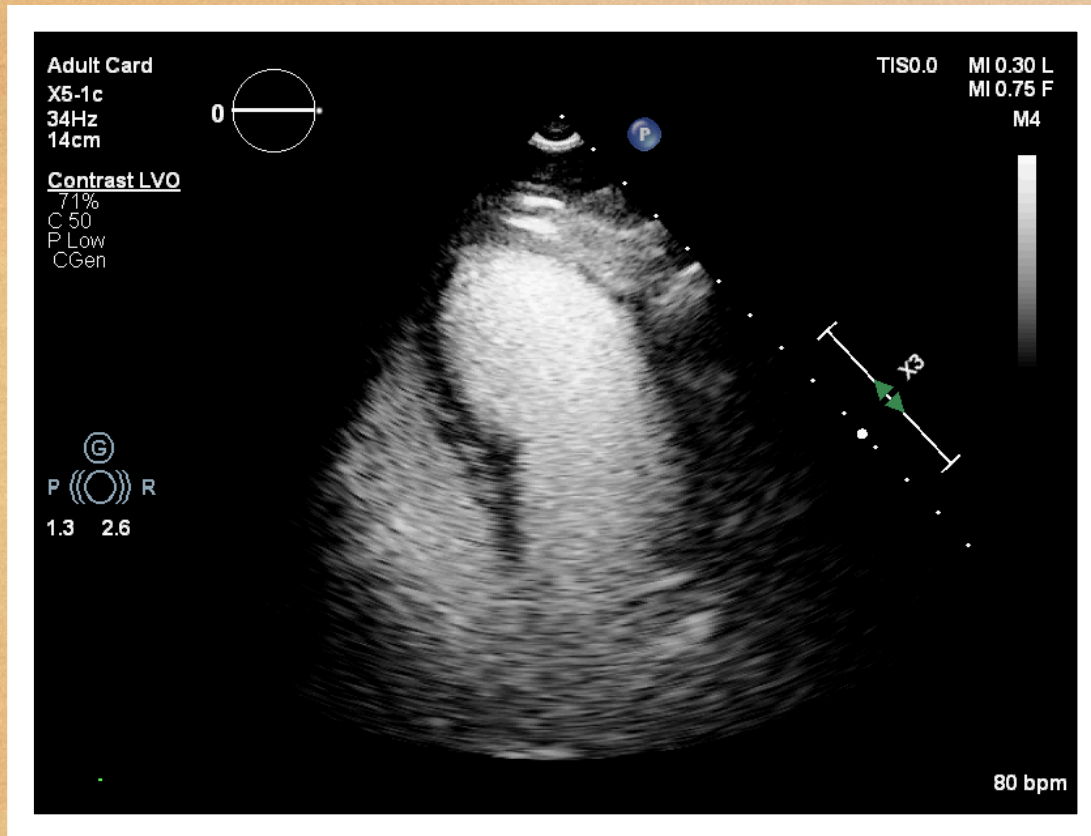
Evaluation of LV Regional Wall Motion



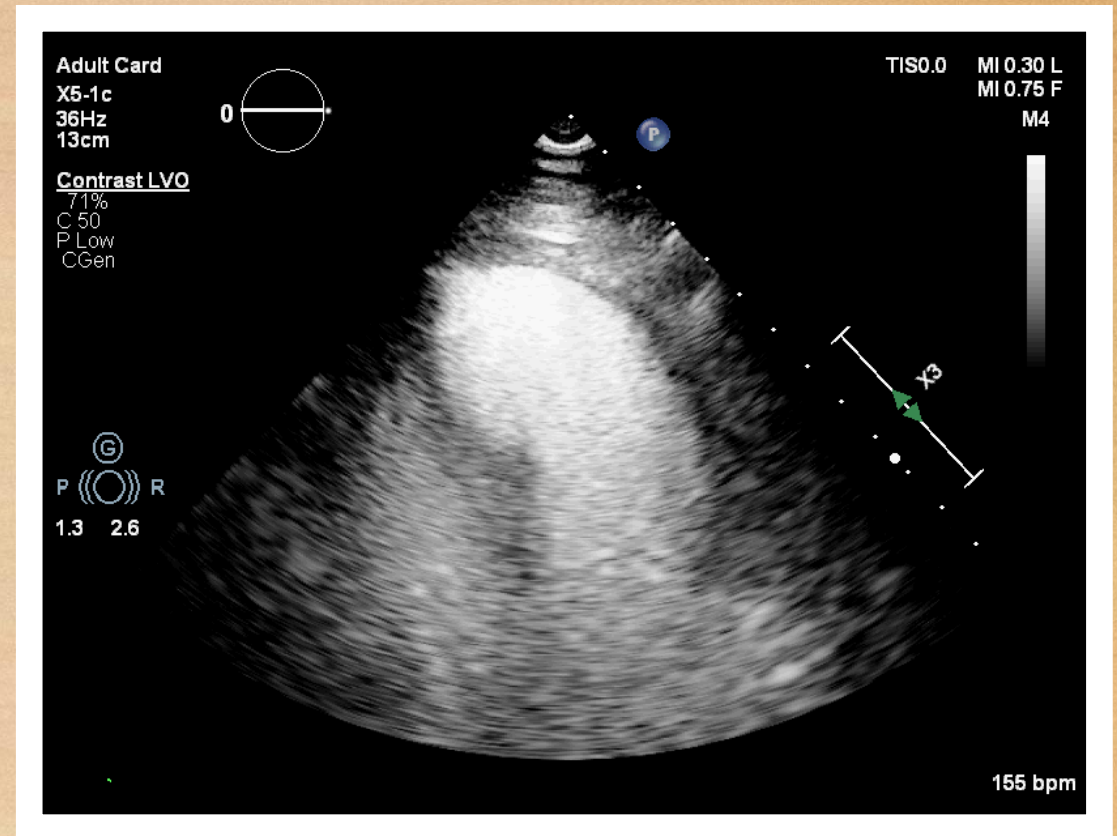
Regional WM Assessment (Subjective)

- Normal
- Hypokinetic
- Akinetic
- Dyskinetic
- Aneurysmal

REST

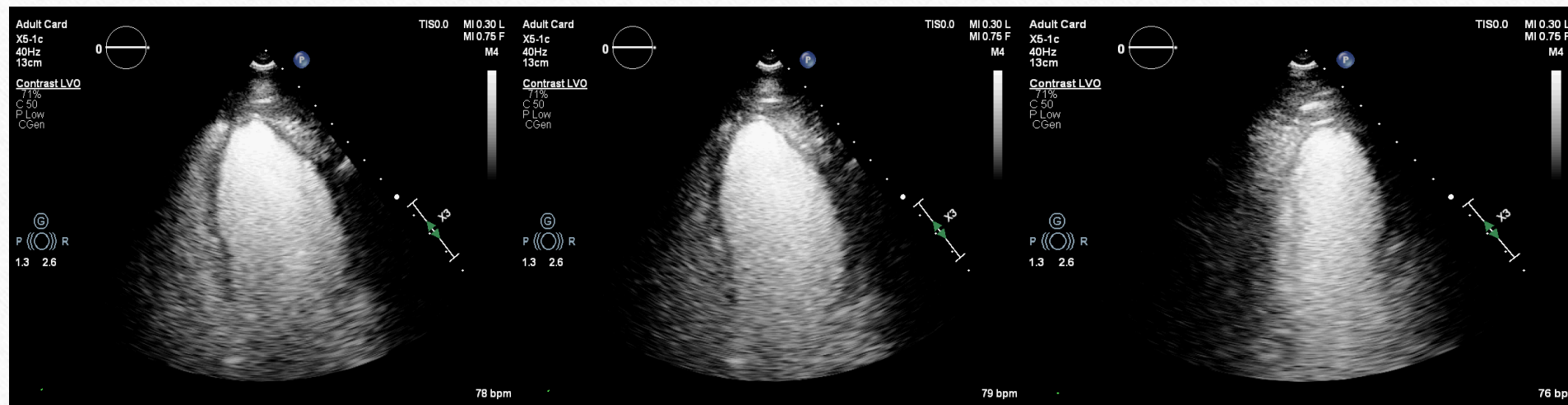


STRESS

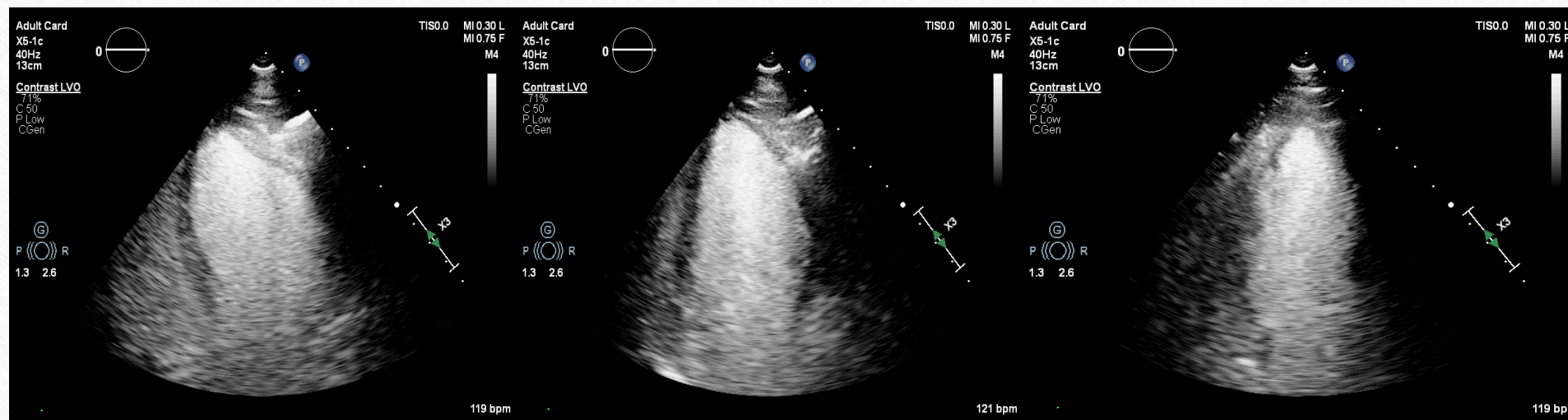




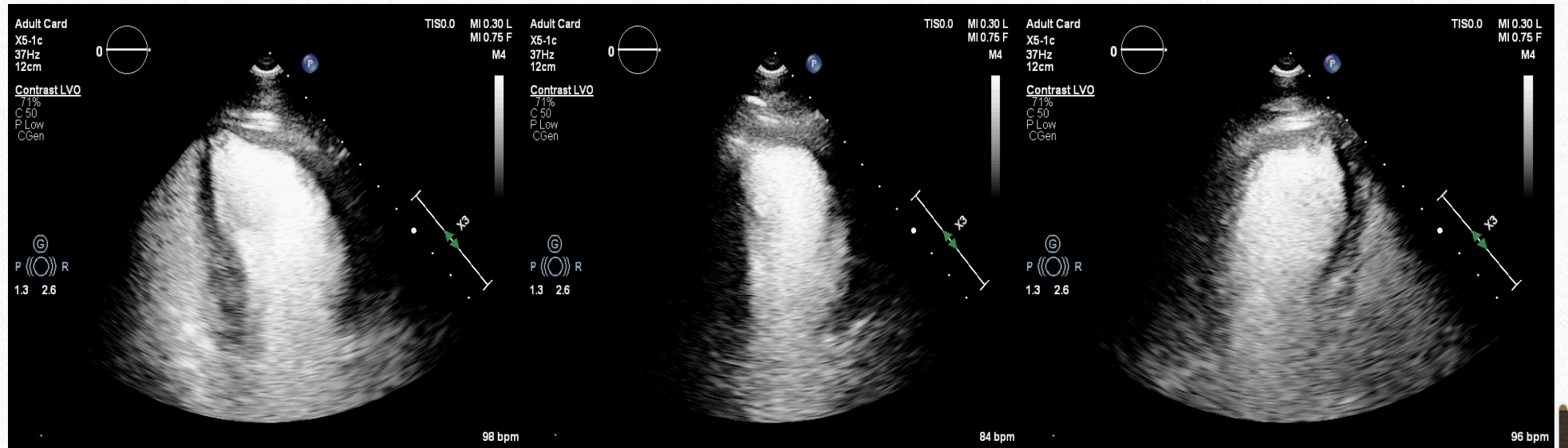
REST



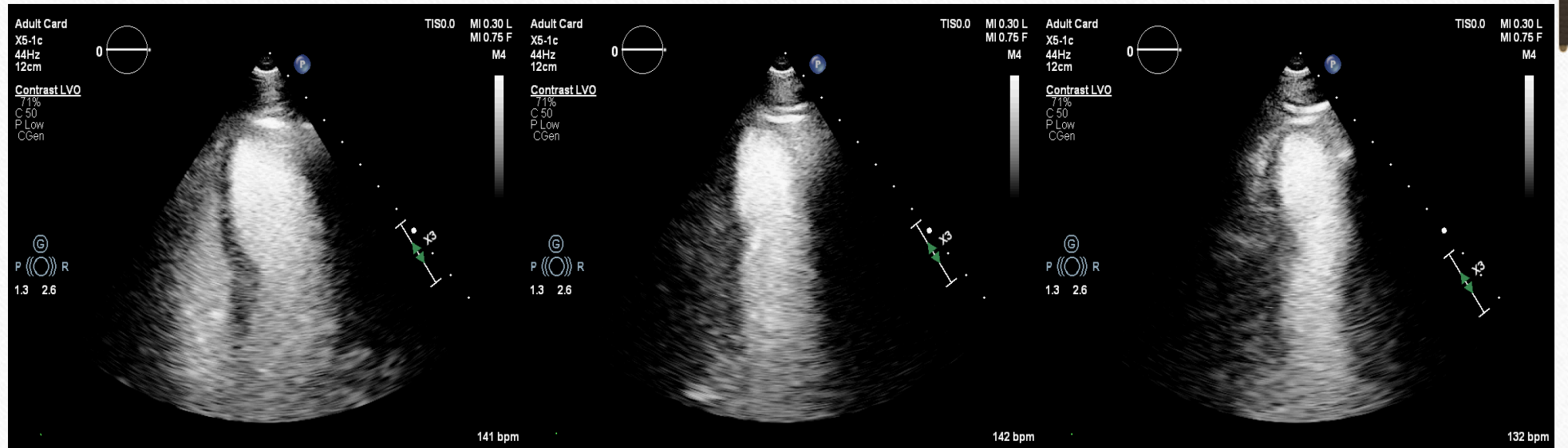
STRESS



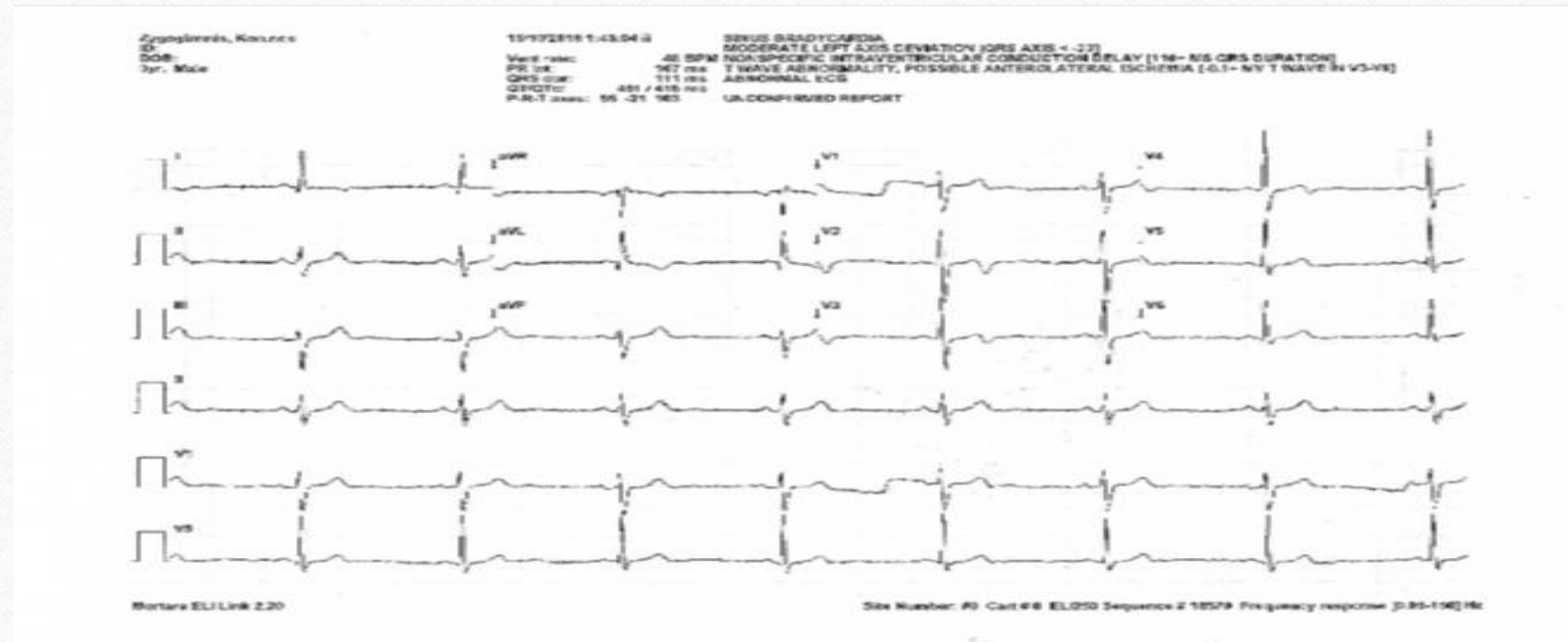
REST



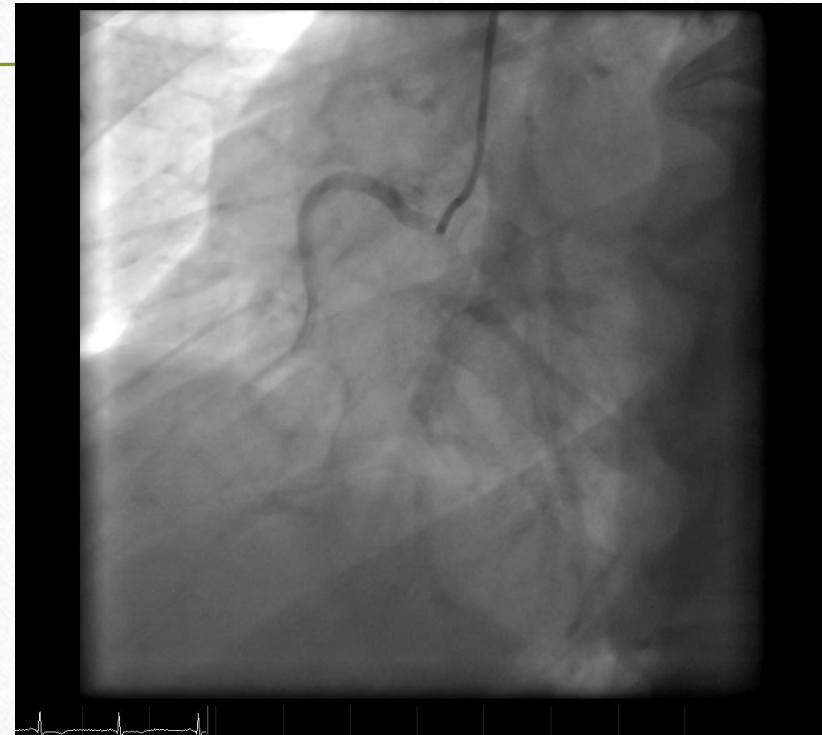
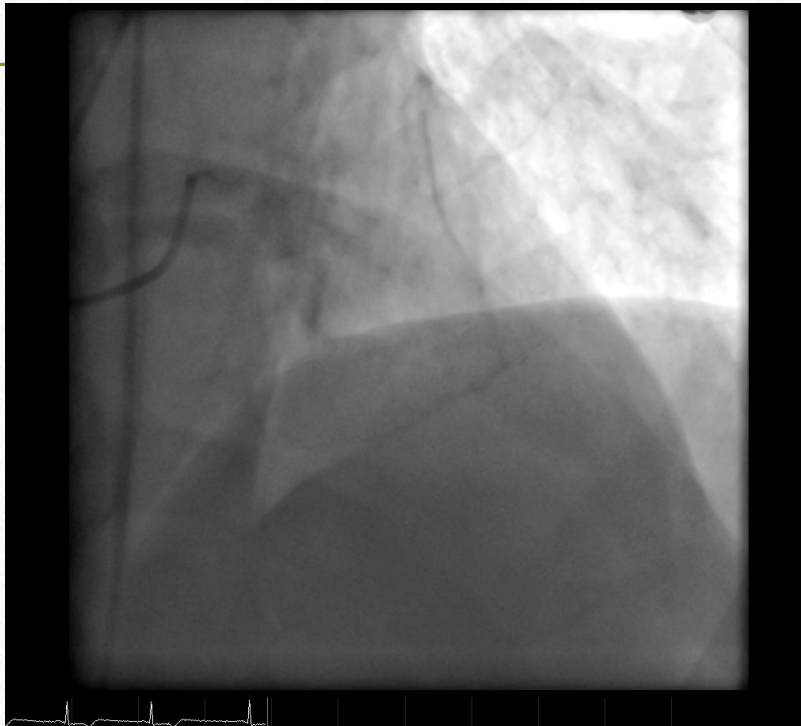
STRESS



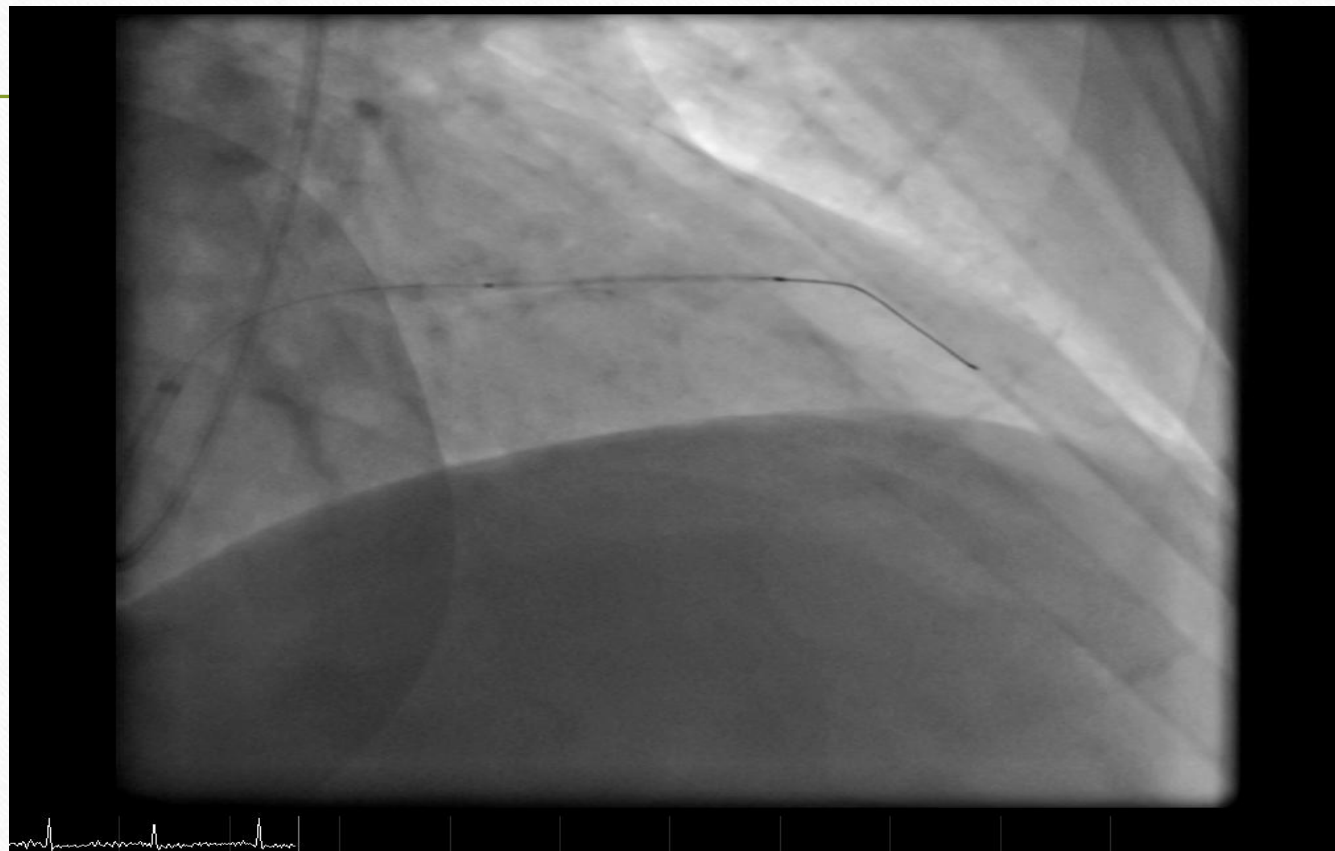
ΑΣΘΕΝΗΣ 60 ΕΤΩΝ ΜΕ ΙΣΤΟΡΙΚΟ ΔΥΣΛΙΠΙΔΑΙΜΙΑΣ ΚΑΙ
ΑΡΤΗΡΙΑΚΗΣ ΥΠΕΡΤΑΣΗΣ ΠΑΡΟΥΣΙΑΖΕΤΑΙ ΜΕ ΟΠΙΣΘΟΣΤΕΡΝΙΚΟ
ΑΛΓΟΣ ΣΕ ΠΕΡΙΦΕΡΕΙΑΚΟ ΝΟΣΟΚΟΜΕΙΟ



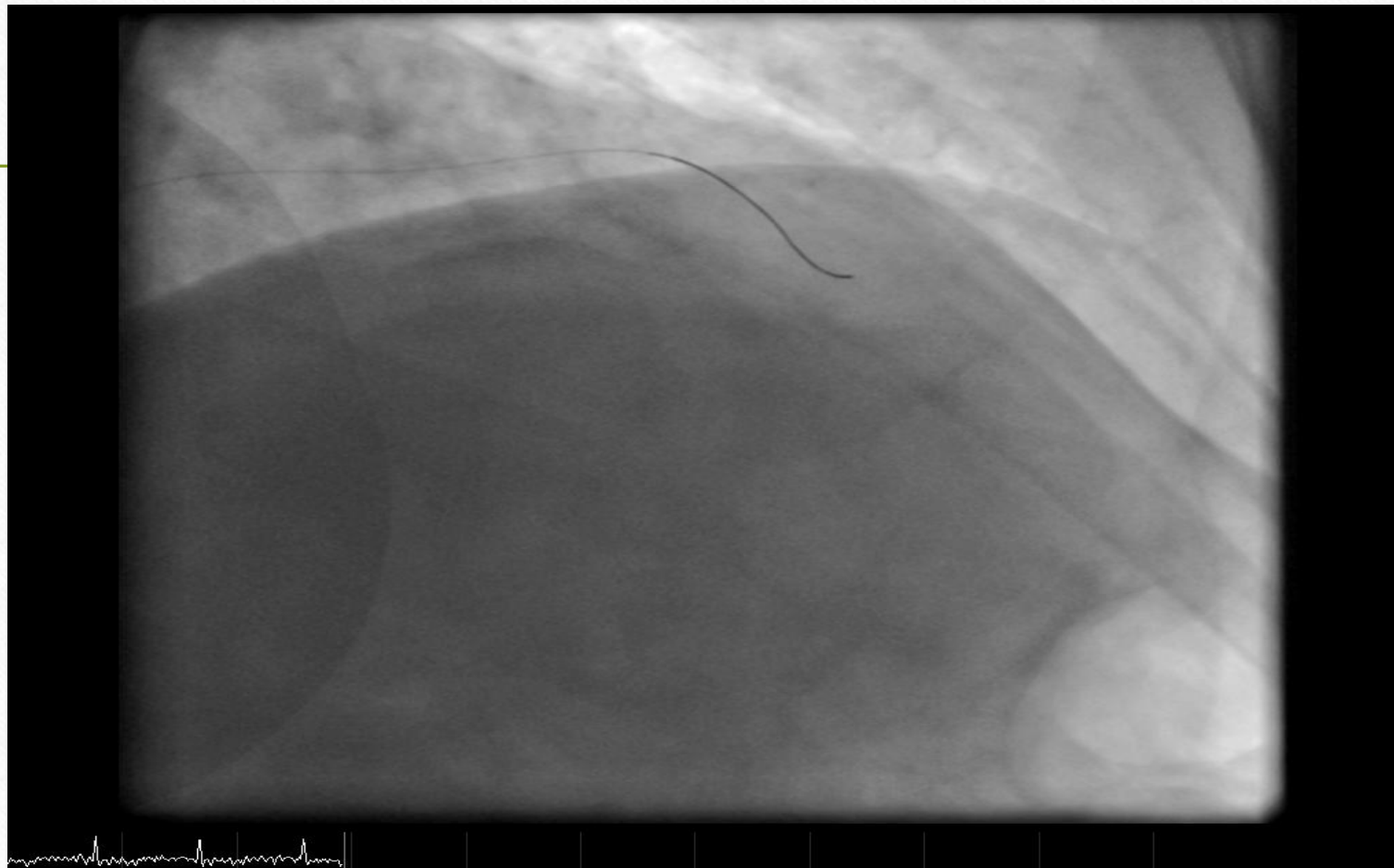
ΥΠΟΒΑΛΛΕΤΑΙ ΑΜΕΣΑ ΣΕ ΣΤΕΦΑΝΙΟΓΡΑΦΙΑ



PCI ΣΤΗΝ ΕΓΓΥΤΕΡΗ ΒΛΑΒΗ ΤΟΥ LAD ΚΑΙ ΣΕ D1, ΑΛΛΑ ΑΔΥΝΑΜΙΑ
ΠΡΟΩΘΗΣΗΣ ΤΟΥ ΣΥΡΜΑΤΟΣ ΠΕΡΙΦΕΡΙΚΟΤΕΡΑ ΣΤΟΝ LAD



ΤΕΛΙΚΟ ΑΠΟΤΕΛΕΣΜΑ: ΚΑΛΗ ΡΟΗ ΣΤΟ ΔΙΑΓΩΝΙΟ ΑΛΛΑ
ΠΑΡΑΜΕΝΕΙ Η ΒΛΑΒΗ ΣΤΟΝ LAD ΣΤΟ ΔΙΧΑΣΜΟ ΜΕ ΤΟ
ΔΙΑΓΩΝΙΟ



Ο ΑΣΘΕΝΗΣ ΠΡΟΣΕΡΧΕΤΑΙ ΣΤΟ ΝΟΣΟΚΟΜΕΙΟ ΜΑΣ
ΓΙΑ ΠΕΡΑΙΤΕΡΩ ΕΚΤΙΜΗΣΗ, ΄ΟΝΤΑΣ ΑΣΥΜΠΤΩΜΑΤΙΚΟΣ
ΓΙΑ 3 ΜΗΝΕΣ

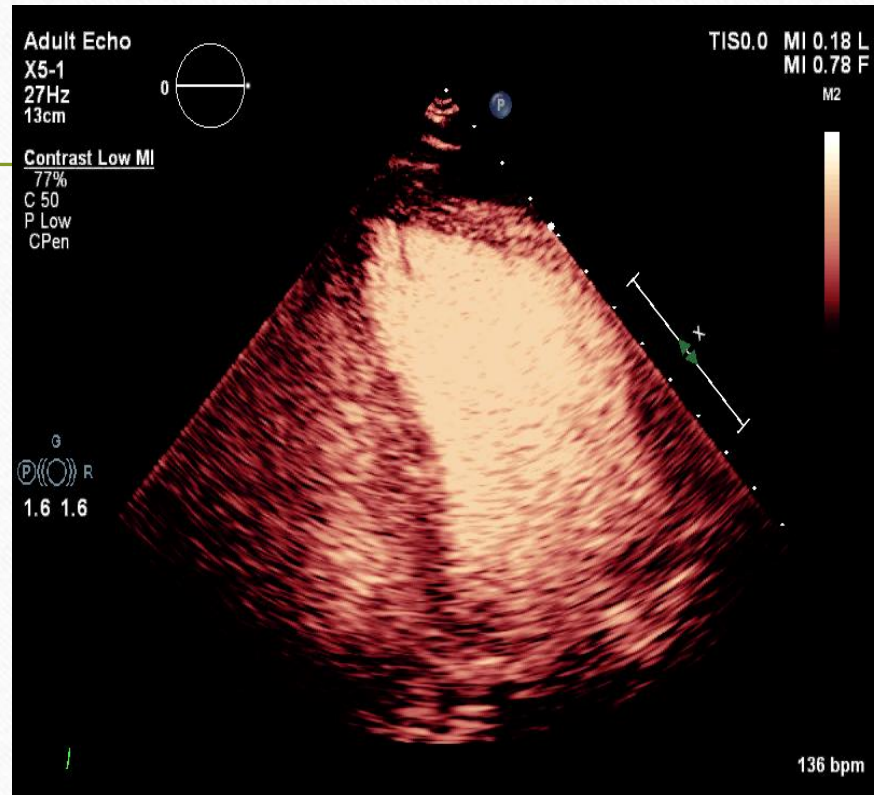
ΕΠΙΛΟΓΕΣ

- 1) ΒΕΛΤΙΣΤΗ ΦΑΡΜΑΚΕΥΤΙΚΗ ΑΓΩΓΗ
- 2) BALLOON ΣΤΟΝ LAD
- 3) 2ο STENT ΣΤΟΝ LAD (CULOTTE, CRUSH, TAP)
- 4) FFR ΣΤΟΝ LAD $\pm$ PCI
- 5) ΕΚΤΙΜΗΣΗ LAD ΜΕ ΜΗ-ΕΠΕΜΒΑΤΙΚΕΣ
ΜΕΘΟΔΟΥΣ

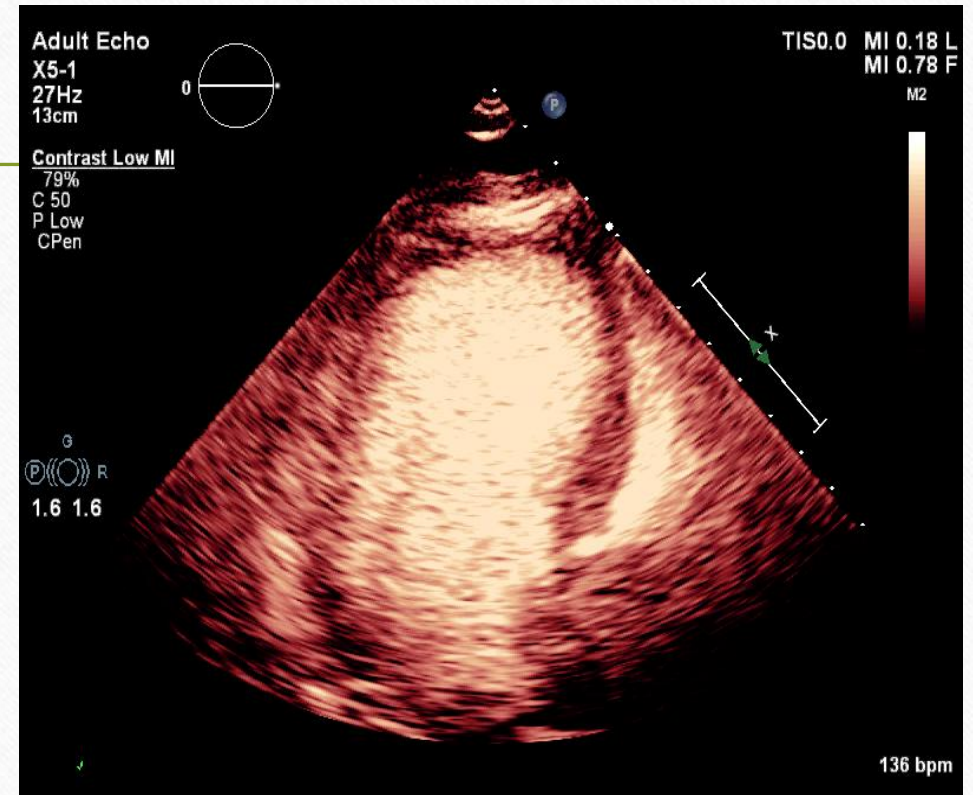
ΑΠΟΦΑΣΙΣΤΗΚΕ Η ΜΗ-ΑΙΜΑΤΗΡΗ ΕΚΤΙΜΗΣΗ ΤΟΥ LAD

- Dobutamine Stress Echo (DSE)
- Perfusion
- CFR στον LAD

DSE 4C



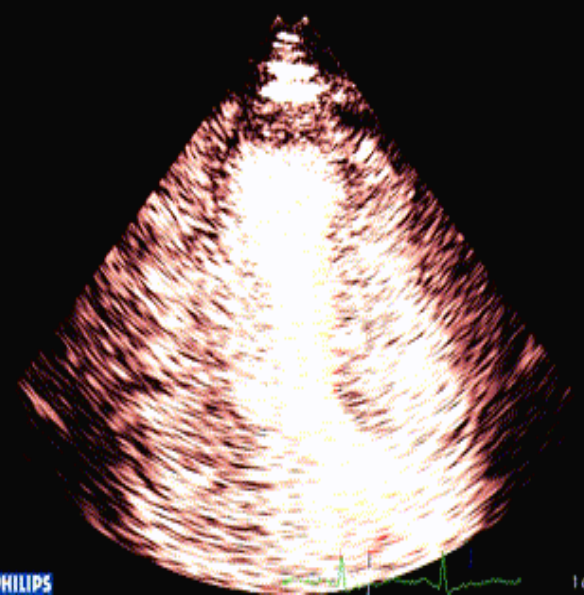
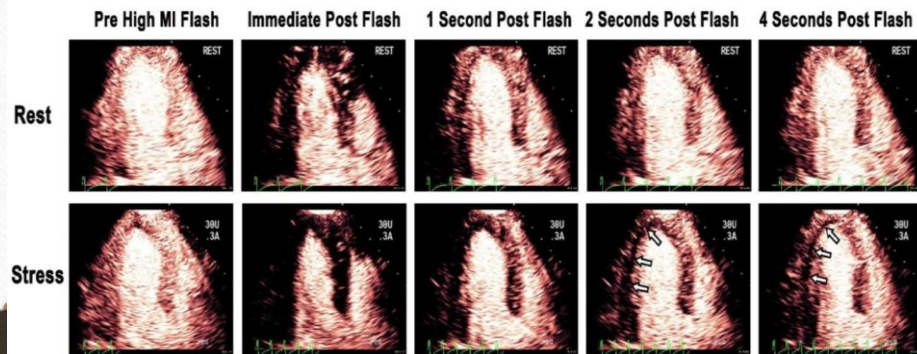
DSE 3C



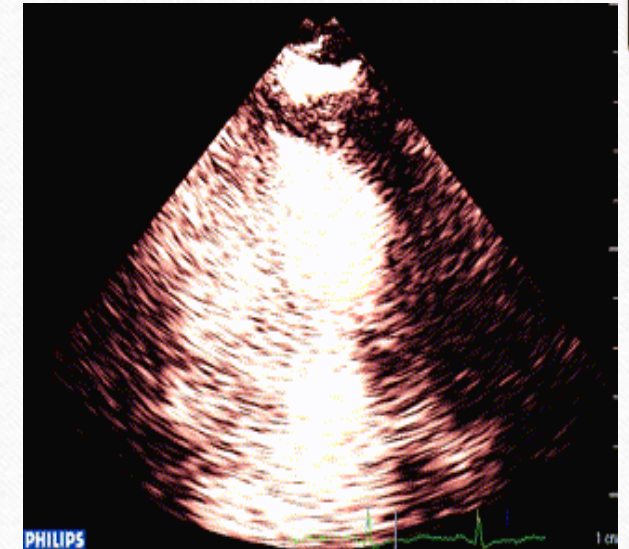
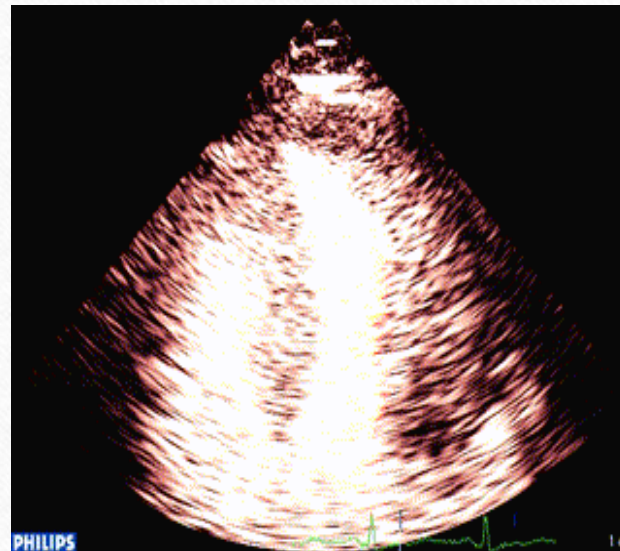
ΑΠΟΦΑΣΙΣΤΗΚΕ Η ΜΗ-ΑΙΜΑΤΗΡΗ ΕΚΤΙΜΗΣΗ ΤΟΥ LAD

- Dobutamine Stress Echo (DSE)
- *Μελέτη αιμάτωσης μυοκαρδίου (perfusion) (real time - low MI)* (ρυθμός πλήρωσης των τριχοειδών του μυοκαρδίου)
- CFR στον LAD

End Systolic Images Side by Side



Demonstration of myocardial contrast replenishment following a high MI impulse during a continuous infusion of UEA during VLMI imaging. Images are acquired near end-systole. When we perform vasodilator stress, we prefer *intermittent high mechanical index imaging*



STRESS ECHO

ΑΓΓΕΙΟΔΙΑΣΤΑΛΤΙΚΕΣ ΟΥΣΙΕΣ

Δυπιριδαμόλη-Αδενοσίνη-Ρεγαδενοσίνη

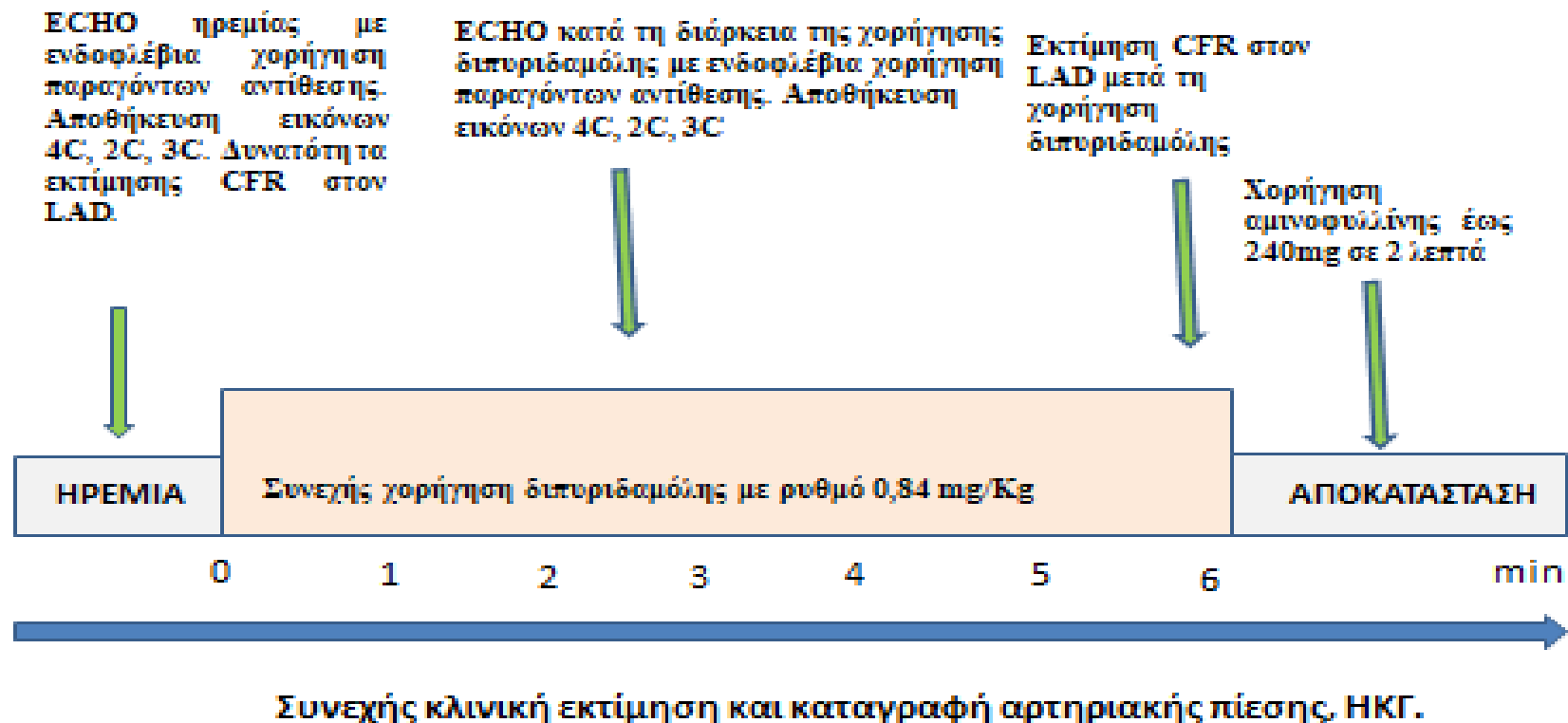
*Δρουν μέσω των
υποδοχέων αδενοσίνης*

*Προκαλούν διαστολή
των στεφανιαίων αγγείων,
αύξηση αιμάτωσης και
πρόκληση πιθανής
ισχαιμίας μέσω
υποκλοπής*

*Εκτίμηση κυρίως της
αιμάτωσης μυοκαρδίου
(perfusion) μέσω
παραγόντων
ηχοαντίθεσης*

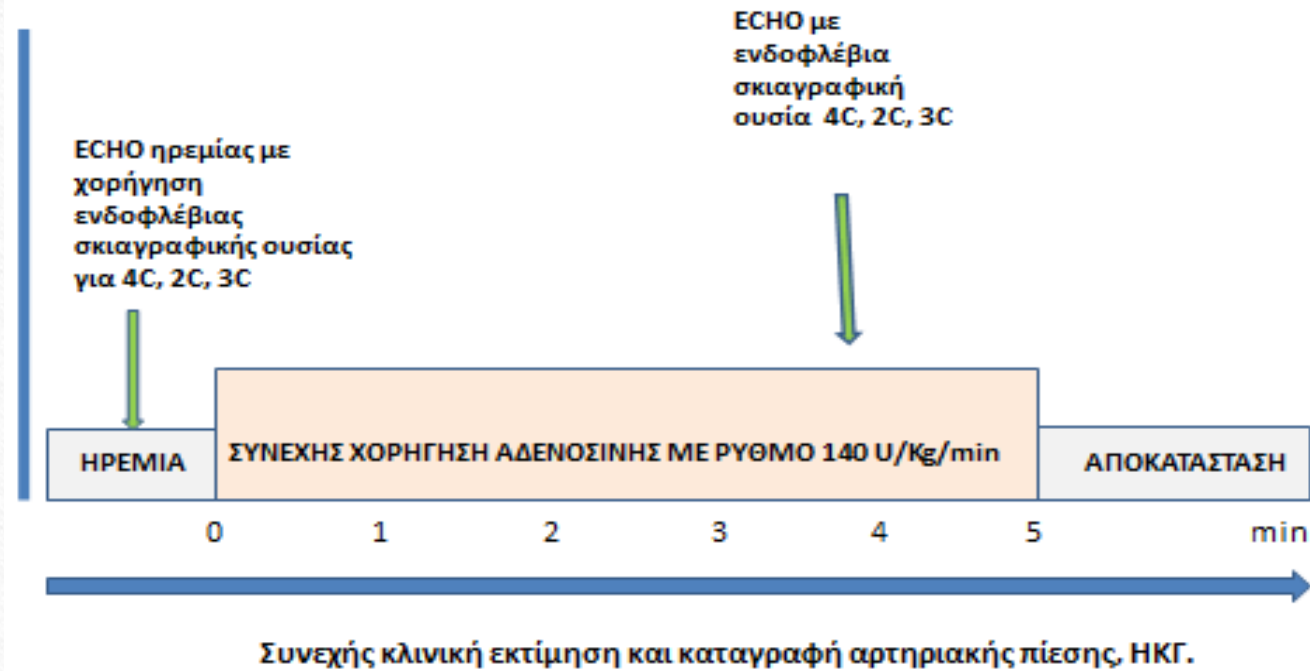
SE PROTOCOLS

STRESS ECHO ΜΕ ΔΙΠΥΡΙΔΑΜΟΛΗ



SE PROTOCOLS

STRESS ECHO ME ΑΔΕΝΟΣΙΝΗ



STRESS ECHO ME REGADENOSON

ECHO ηρεμίας με
ενδοφλέβια χορήγηση
παραγόντων αντίθεσης.
Αποθήκευση εικόνων
4C, 2C, 3C.



HPEMIA

0

ECHO μετά τη χορήγηση regadenoson
με ενδοφλέβια χορήγηση παραγόντων
αντίθεσης. Αποθήκευση εικόνων 4C,
2C, 3C



2



4



6

min

Συνεχής κλινική εκτίμηση και καταγραφή αρτηριακής πίεσης, ΗΚΓ.

Regadenoson Contra-indications

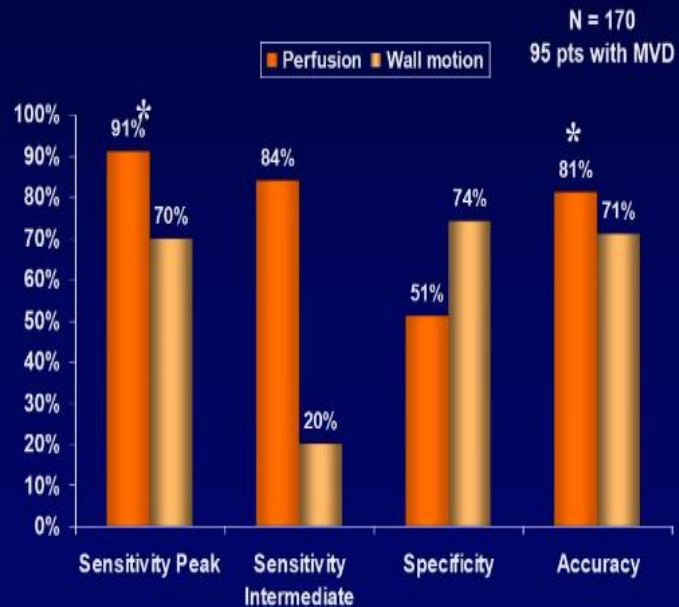
- Severe asthma, COPD (active wheezing)
- Hypotension (<90 SBP)
- Severe bradycardia (<40 bpm)
- Xanthines, caffeine (12 hrs)
- Recent use of dipyridamole (e.g., aspirin) within 48 hrs
- Aminophylline within 24 hours
- High degree AV block/sick sinus syndrome

Common side effects	
Headaches	29%
Dyspnea	25%
Flushing	17%
Chest discomfort	11%
Chest pain	8%
Angina	8%
Dizziness	7%
Nausea	6%
Abdominal discomfort	6%

Reversal agent: Aminophylline

Perfusion imaging in DSE

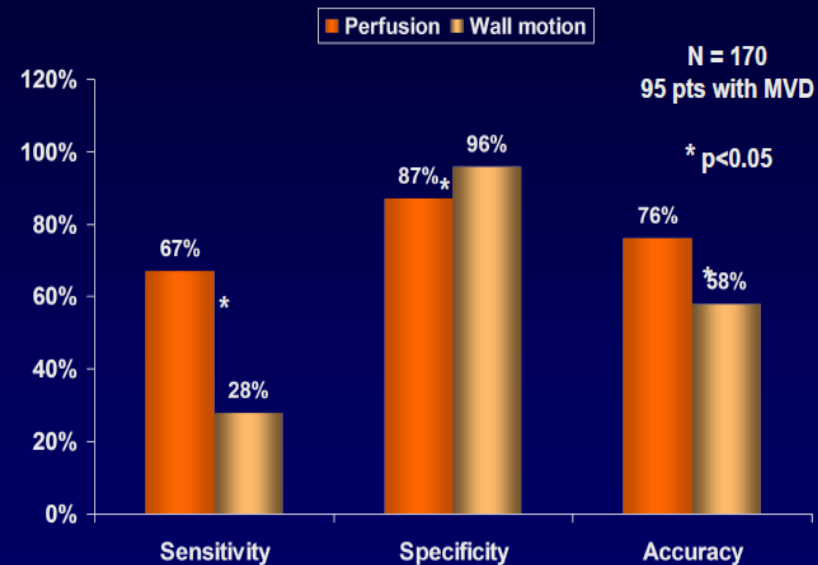
'Real-time' Low-MI Dobutamine MCE



Elhendy et al. JACC 2004;44:2185-2191.

12/7/2018 32

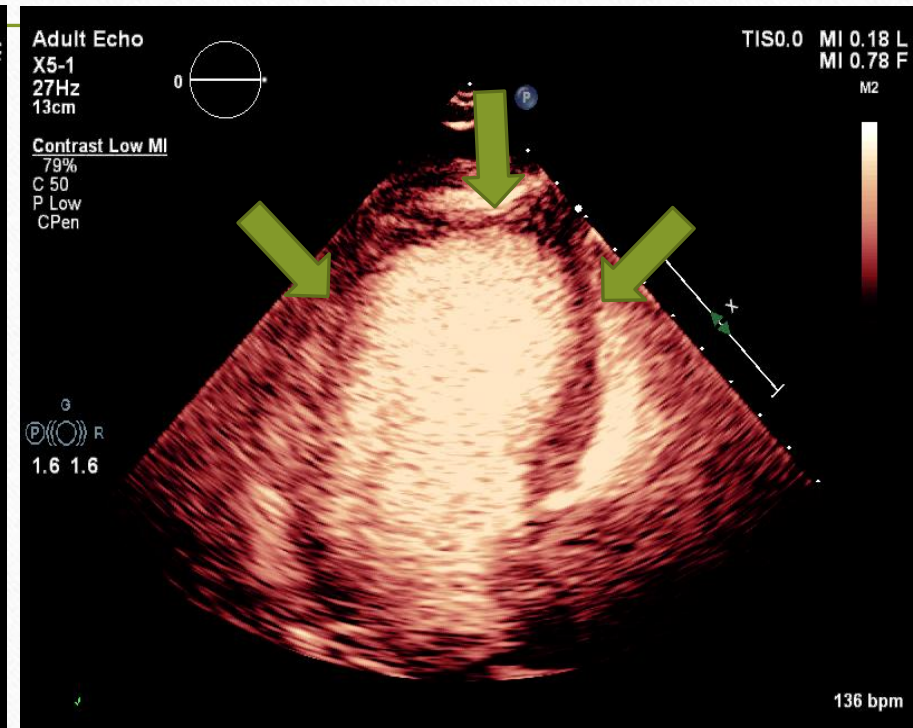
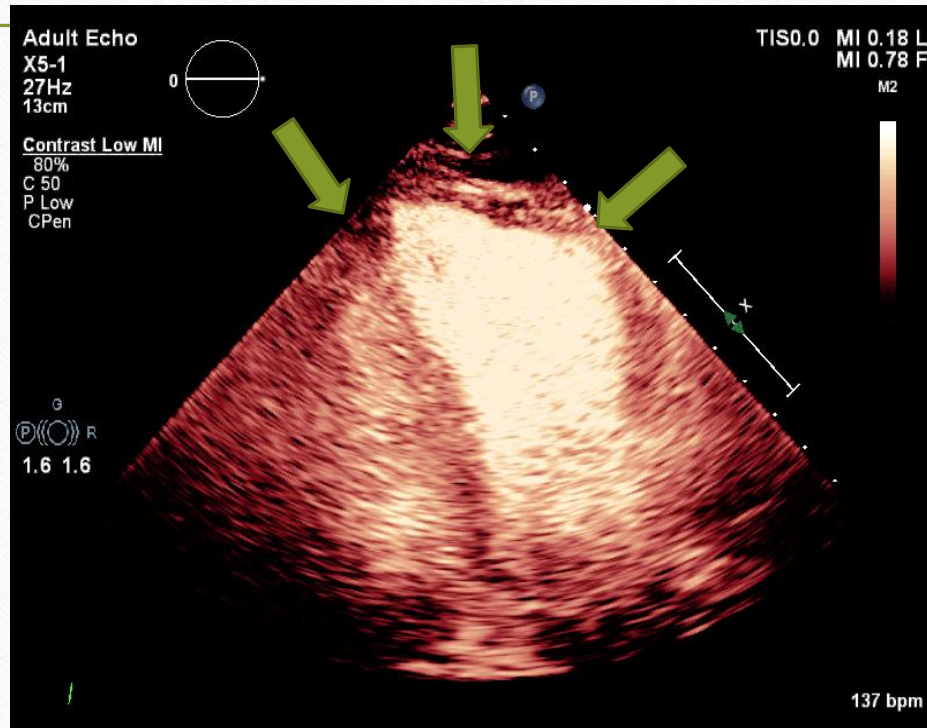
Detecting Multivessel CAD



Elhendy et al. JACC 2004;44:2185-2191.

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ΠΑΘΟΛΟΓΙΚΟ “PERFUSION” ΚΟΡΥΦΗΣ

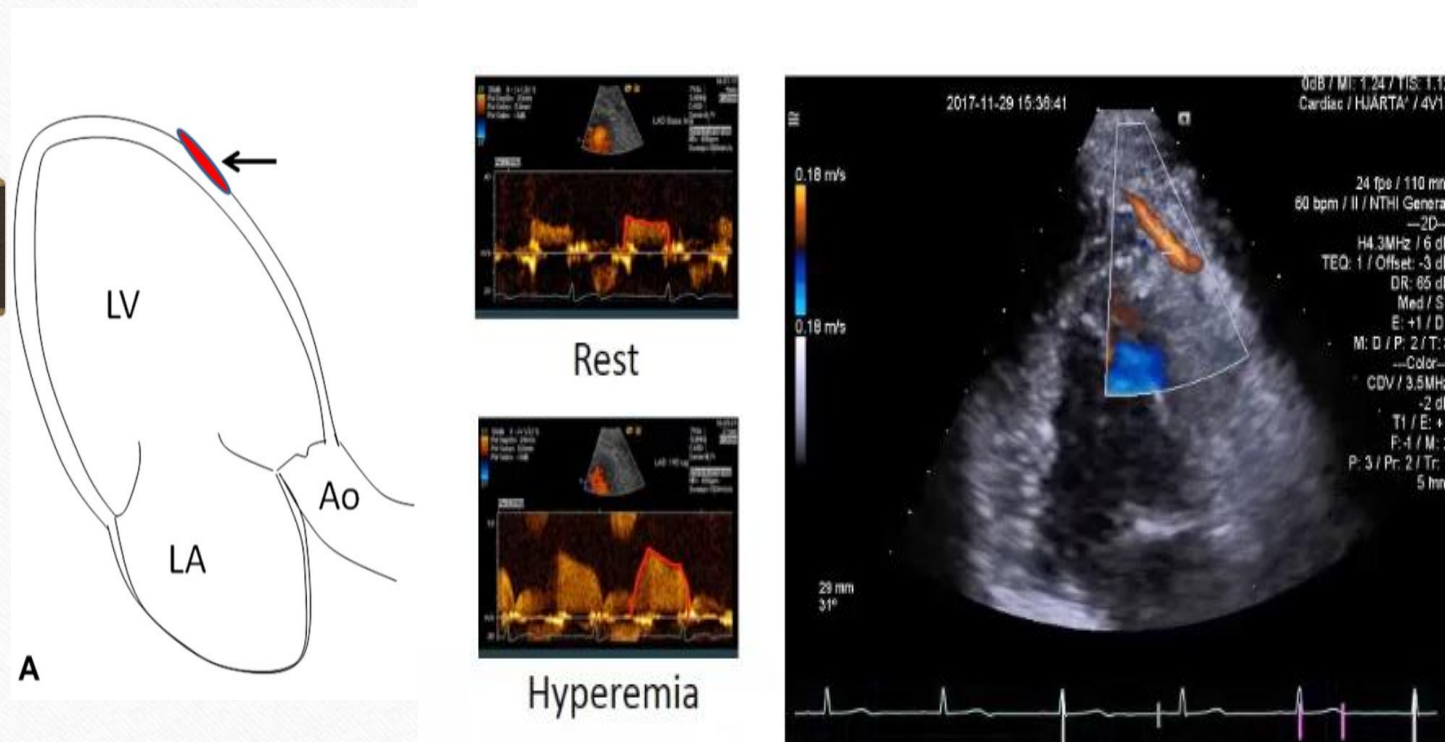


ΑΠΟΦΑΣΙΣΤΗΚΕ Η ΜΗ-ΑΙΜΑΤΗΡΗ ΕΚΤΙΜΗΣΗ ΤΟΥ LAD

- Dobutamine Stress Echo (DSE)
- *Μελέτη αιμάτωσης μυοκαρδίου (perfusion) (real time - low MI)* (ρυθμός πλήρωσης των τριχοειδών του μυοκαρδίου)
- CFR στον LAD

- **Εφεδρεία ροής (Coronary Flow Reserve):** Η δυνατότητα του στεφανιαίου αγγείου να αυξήσει τη ροή του σε αυξημένες μεταβολικές ανάγκες του μυοκαρδίου

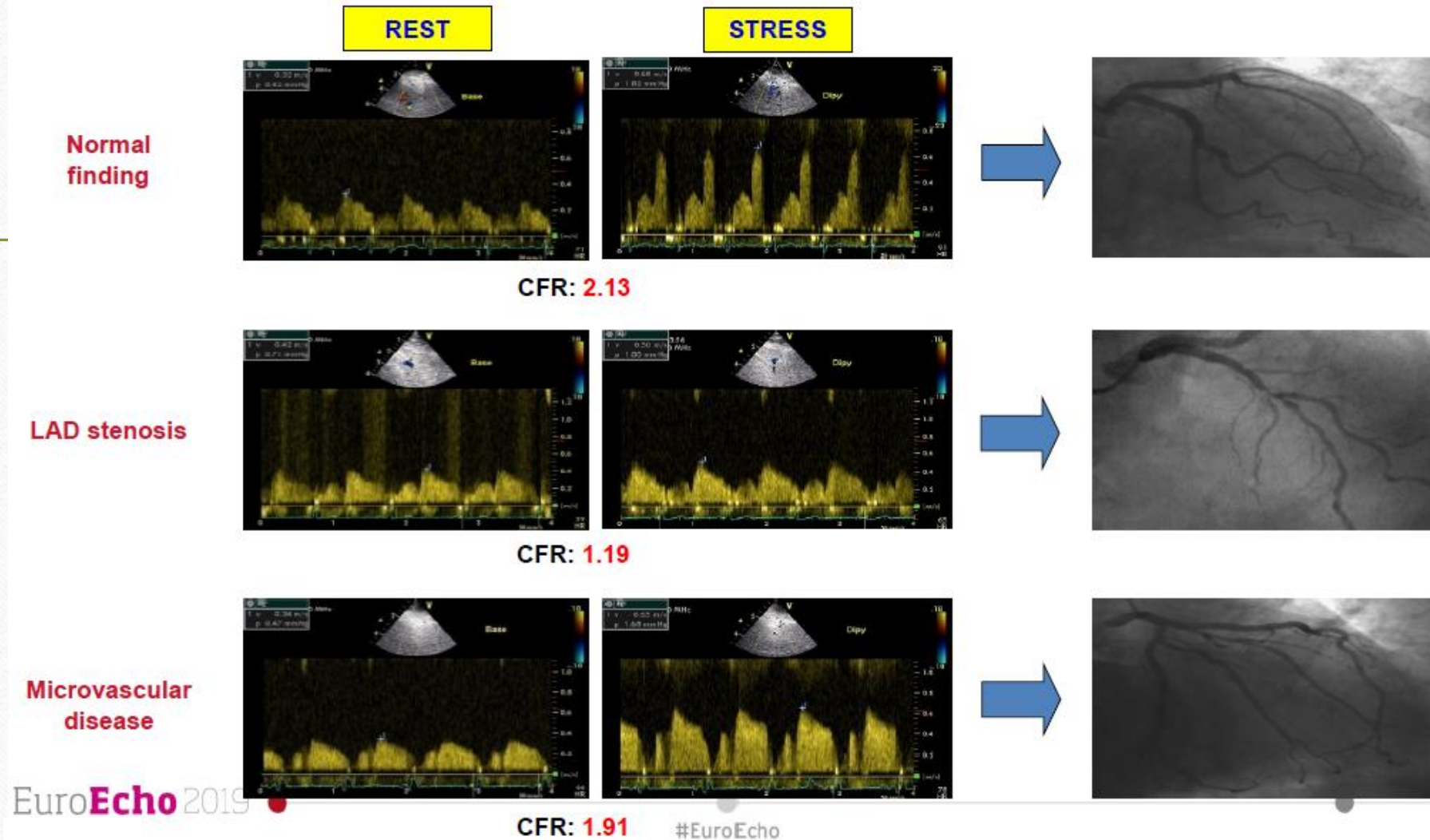
Modified 2-3CH view



- Μετράται η κορύφωση της διαστολικής ροής
- Συνήθως mid-distal LAD
- $CFR = V_{max} \text{ hyperemia} / V_{max} \text{ rest}$
- Values: > 2,5 normal
< 2 pathologic
2-2,5 grey zone

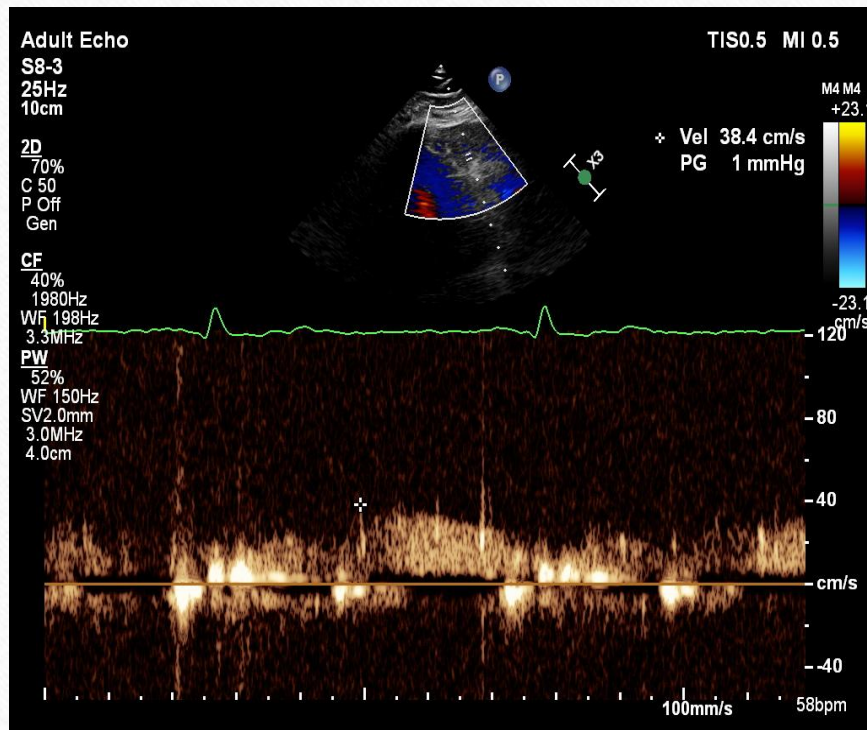
Interpretation - Significance

detecting significant ($> 75\%$) LAD stenosis with a *sensitivity of 86% and a specificity of 70%*

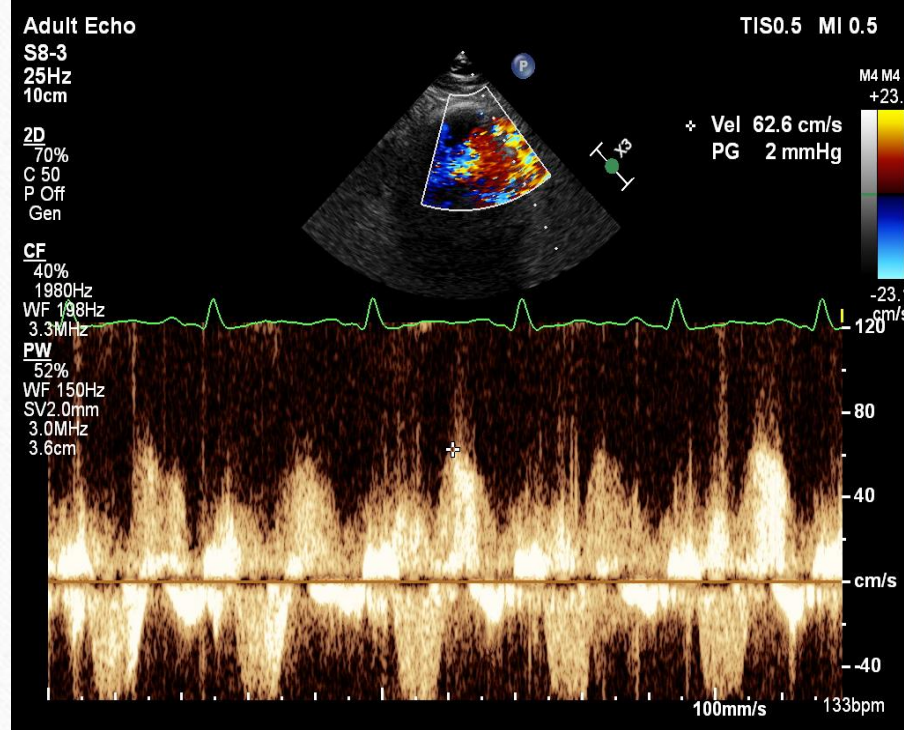


CFR 1,85

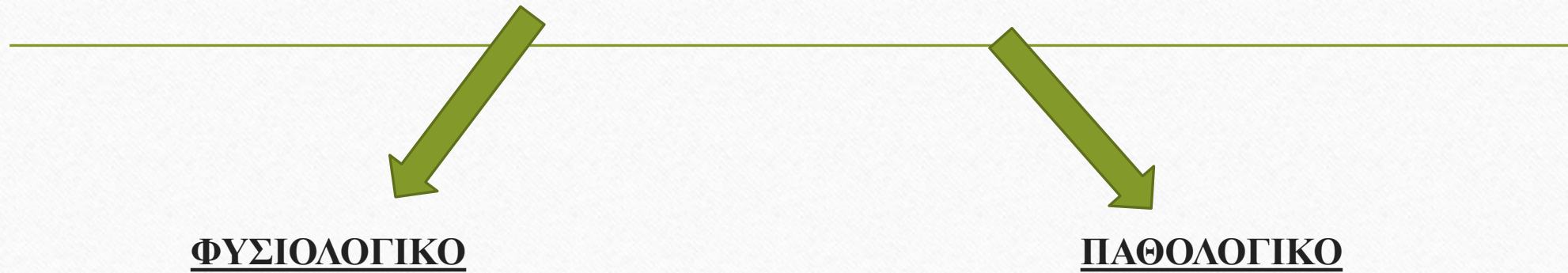
HPEMIA



STRESS



ΑΓΓΕΙΟΓΡΑΦΙΚΑ “ΜΑΛΛΟΝ” ΣΗΜΑΝΤΙΚΗ ΝΟΣΟΣ ΣΤΟΝ LAD



❖ WALL MOTION

❖ ΔΟΚΙΜΑΣΙΑ ΚΟΠΩΣΕΩΣ

❖ PERFUSION

❖ CFR

ΤΕΛΙΚΗ ΑΠΟΦΑΣΗ

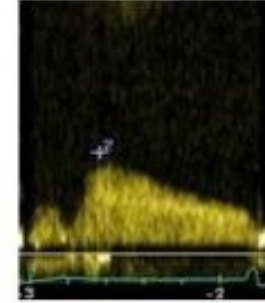
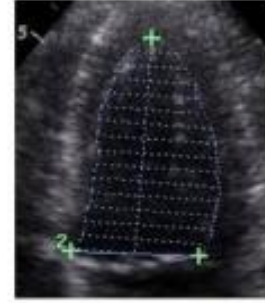
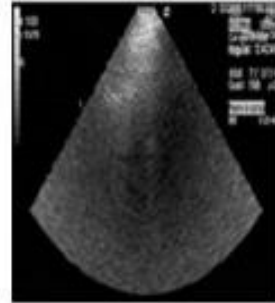
- ❖ CFR και PERFUSION δεν αποτελούν “stand alone” απεικονιστικές μέθοδοι ανάδειξης ισχαιμίας → προσθετική μόνο η αξία τους (προς το παρόν!!!)
- ❖ Ασυμπτωματικός ο ασθενής μετά την προηγούμενη αγγειοπλαστική



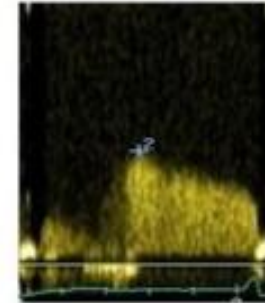
Συντηρητική αντιμετώπιση - στενό follow up

ABCDE Stress Echo

Rest



Stress



RWMA

B-lines

LVCR

CFVR

HRR

A

B

C

D

E

Risks: stress and contrast

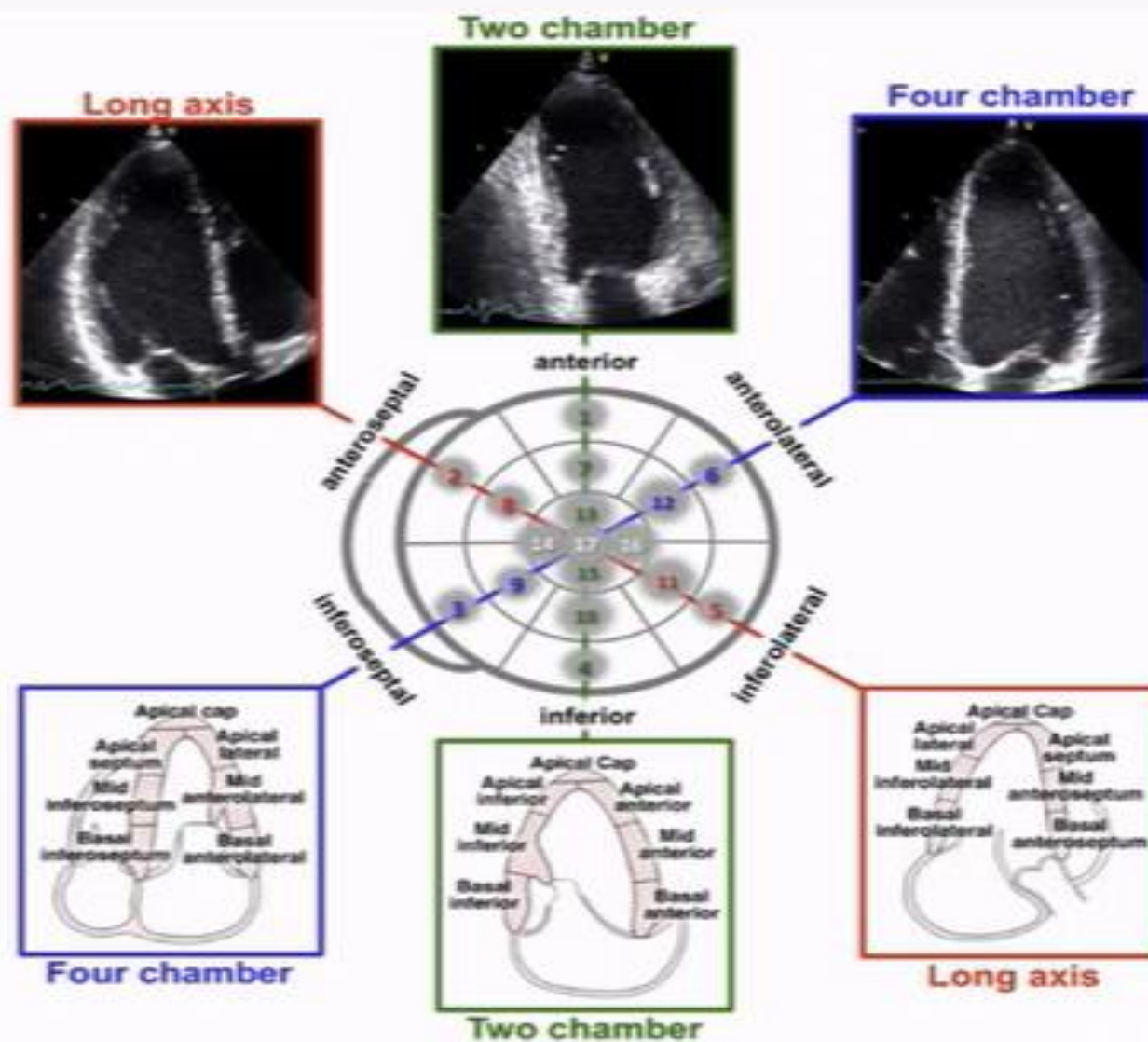
The stress risk is in the order of magnitude of 1 major life-threatening event every 1000 studies,

The frequency of side effects with UCAs is extremely low (1 in 10 000) for life-threatening anaphylaxis reactions

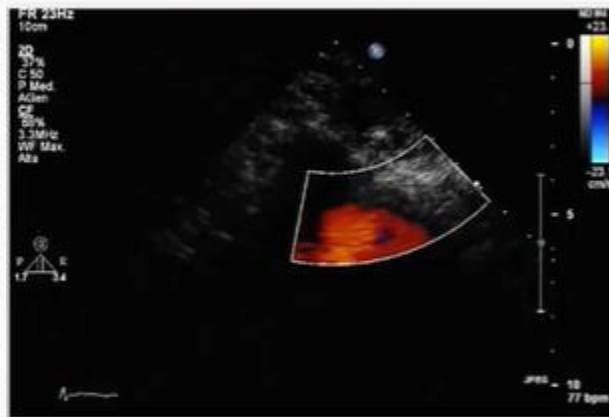
Other symptoms such as headache, chest pain, and back pain are more frequent but less severe

STRESS ECHO vs CCTA

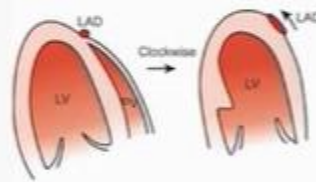
	SE	CCTA
Approach	Functional testing	Anatomic testing
Preferred based on ESC 2019	Intermediate-high probability	Low probability
Downstream revascularizations	Lower rate	Higher rate
Pre-obstructive atherosclerosis	Carotid ultrasound needed	Detects higher-risk patients
Warranty period expiration	1 year	2 years
Cost EU (€)	97 (50–165)	274 (98–509)
Cost USA (\$)	2600 (200–5000)	4200 (625–12 700)
Radiation (mSv)	0	4 (0.5–10)
Radiation (CXRs)	0	200 (25–500)
CO ₂ emission (kg per scan)	0.5–2.0 kg	9 kg
CO ₂ equivalent (modern car)	4 km	74 km



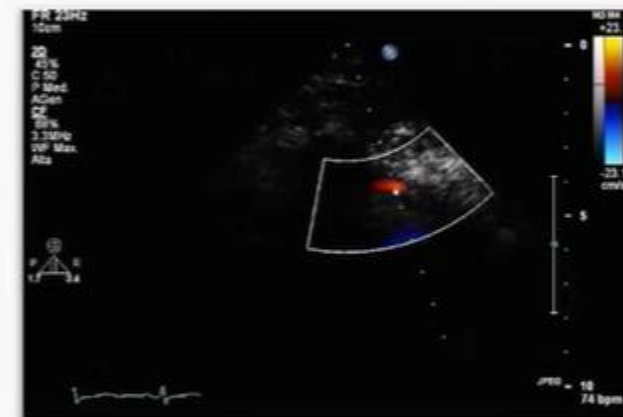
Rest no contrast, no visible LAD flow

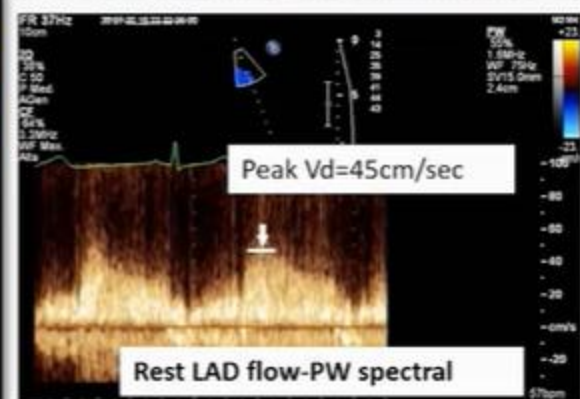
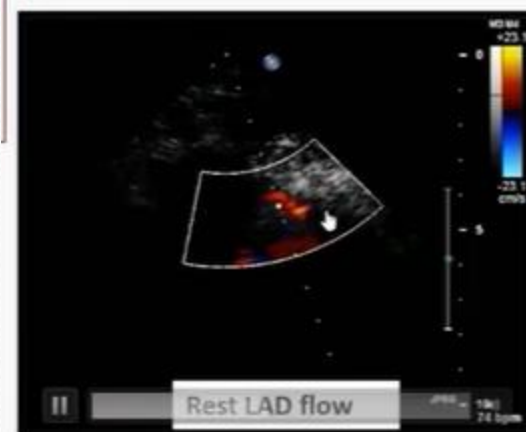
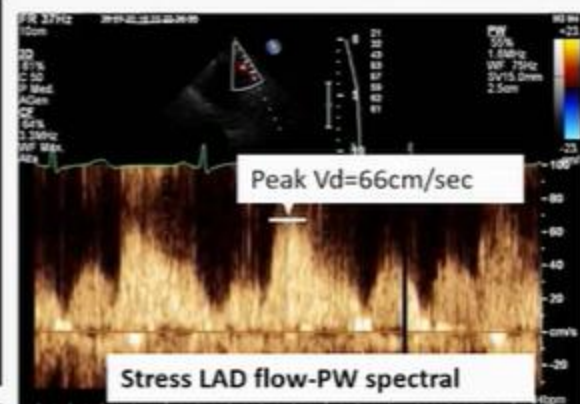


Luminy small bolus



Contrast bolus facilitates detection of Rest LAD flow





2022 ESC Guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery

Stress imaging

Stress imaging should be considered before high-risk NCS in asymptomatic patients with poor functional capacity, and previous PCI or CABG.

IIa

Table 5 Surgical risk estimate according to type of surgery or intervention

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



European Society
of Cardiology

European Heart Journal (2024) 45, 3415–3537

<https://doi.org/10.1093/eurheartj/ehae177>

ESC GUIDELINES

2024 ESC Guidelines for the management of chronic coronary syndromes

Recommendations	Class ^a	Level ^b
In individuals with suspected CCS and moderate or high (>15%–85%) pre-test likelihood of obstructive CAD, stress echocardiography is recommended to diagnose myocardial ischaemia and to estimate the risk of MACE. ^{33,241–246}	I	B

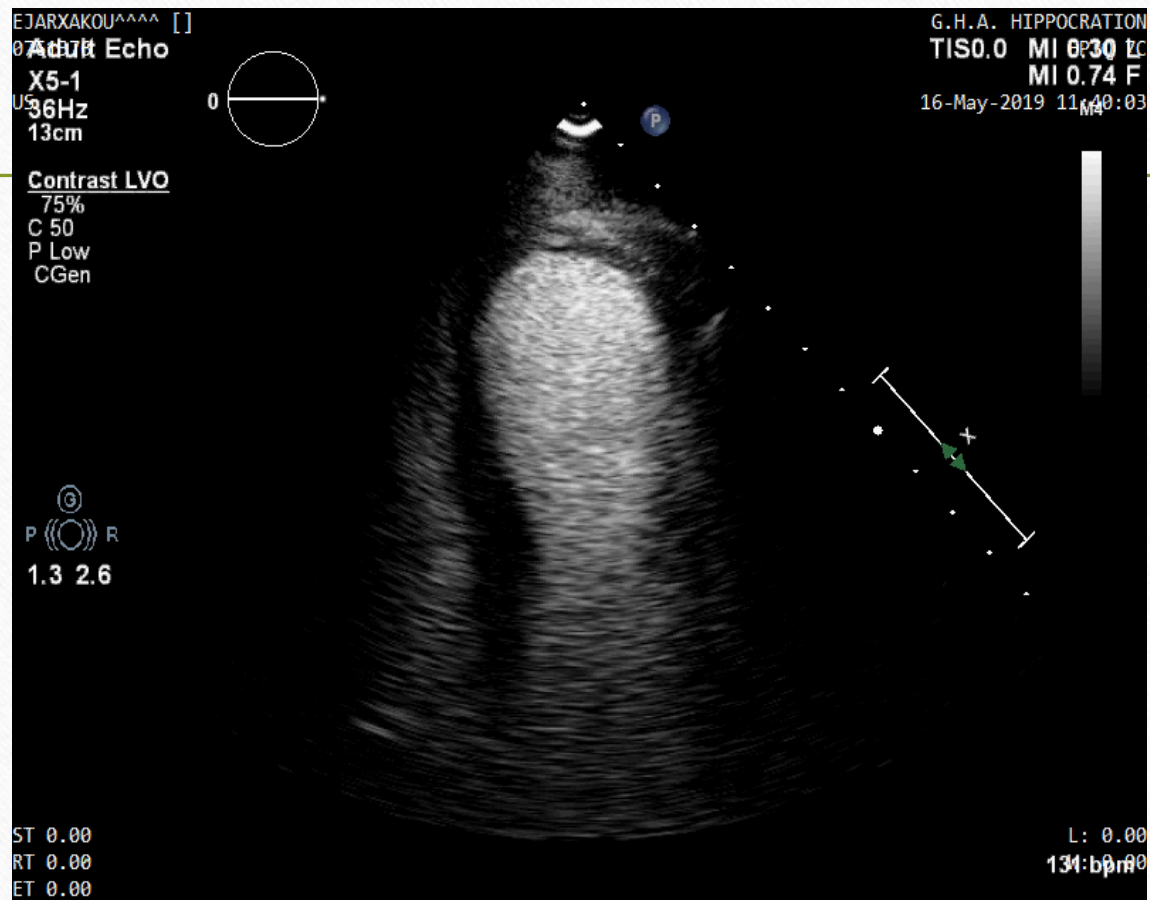
Stress Echo	LVEF and volumes
	Wall motion abnormalities
	Myocardial perfusion
	Coronary velocity flow reserve

ΑΝΤΕΝΔΕΙΞΕΙΣ

ΣΧΕΤΙΚΕΣ

-
- *Αρρυθμιστη αρτηριακή υπέρταση*
 - *Διαταραχές κολποκοιλιακής αγωγής*
 - *Διαταραχές καλίου*

STRESS ECHO



STRESS ECHO

