

Stress Echo in coronary artery disease

**Stefanos Karagiannis MD PhD
Cardiologist
Director Echocardiology Dept
ATHENS MEDICAL CENTER**

Conflicts: none

Stress echo protocols

	Equipment	Protocols
Exercise	Semi-supine bicycle ergometer	25 W x 2' with incremental loading
Dobutamine	Infusion Pump	5 mcg/Kg/min 10-20-30-40 + atropine (0.25 x 4) up to 1 mg
Dipyridamole	Syringe	0.84 mg/Kg in 6' or 0.84 mg/Kg in 10' + atropine (0.25 x 4) up to 1 mg
Adenosine	Syringe	140 mcg/Kg/min in 6'
Pacing	External Pacing	From 100 bpm with increments of 10 beats/min up to target heart rate

DSE protocol

- Resting two-dimensional echocardiographic examination from the standard apical and parasternal views.
- Dobutamine is administered intravenously by infusion pump, starting at: 5 $\mu\text{g}/\text{kg}/\text{min}$ for 3 minutes, followed by 10 $\mu\text{g}/\text{kg}/\text{min}$ for 5 minutes and increasing by 10 $\mu\text{g}/\text{kg}/\text{min}$ every 3 minutes to a maximum of 40 $\mu\text{g}/\text{kg}/\text{min}$ (stage 5), and continued for 6 minutes.
(Dobutamine exerts its effect by stimulation of β_1 , β_2 , and α_1 -adrenergic receptors)
- During the test, a 12-lead ECG is recorded every minute. Blood pressure was measured every 3 minutes.

DSE protocol

- Stop if a target heart rate (85% of a theoretic maximal heart rate (men: $(220 - \text{age}) \times 85\%$; women: $(200 - \text{age}) \times 85\%$) is achieved.
- If the target heart rate is not achieved and patients have no symptoms or signs of ischemia, atropine (starting with 0.25 mg, increased to a maximum of 1.0 mg) is given intravenously at the end of stage 5 while the dobutamine administration is continued.
- IV beta-blocker is administered (1,0 to 5,0 mg) intravenously according to heart rate response and systolic blood pressure, and after peak stress images are acquired to achieve a recovery phase, defined as heart rate within 10% range of resting heart rate.
(Acute β -blockade interacts with dobutamine β 1 receptors leaving unopposed β 2 and primarily α 1-adrenergic vasoconstriction and therefore leading to reduction of coronary flow reserve.)

The criteria for stopping the test are:

- (1) achievement of the target heart rate
- (2) severe and extensive NWMA
- (3) symptomatic decline in systolic blood pressure of more than 40 mmHg, or a systolic blood pressure \leq 90 mmHg
- (4) hypertension (blood pressure $>240/140$ mmHg)
- (5) the occurrence of sustained cardiac arrhythmias
- (6) severe angina pectoris
- (7) intolerable adverse effects considered to be the result of dobutamine or atropine.

CAD detection (DIAGNOSIS)

- Regional function is scored according to a 16/17segment, five point scoring model: 1, normal; 2, mildly hypokinetic; 3, severely hypokinetic; 4, akinetic; and 5, dyskinetic.
- The extent and location of ischemia are evaluated.
Wall-motion score index (WMSI) (total score divided by the number of segments scored) is calculated, at rest, low dose, during peak stress, and during the recovery phase.
- The results of DSE are considered positive if NWMA occur (i.e., if wall motion in any segment worsens by ≥ 1 grades during the test, with the exception of akinesis becoming dyskinesis).

NWMA : look at thickening

Δυναμική μελέτη με έγχυση Δοβουταμίνης
(Stress Echo-DSE)

Όνοματεπώνυμο:

Ηλικία:

Ημ/νια:

Κλινικές Πληροφορίες:

Έκθεση:

Μετά λήψη εικόνων σε ηρεμία, έγινε έγχυση δοβουταμίνης με ρυθμό 5, 10, 20, 40 μg/kg/min, handgrip και έγχυση ηχοαντιθετικού μέσου και mg atropine.

ΑΠ: ηρεμία (rest): mmHg

ΑΠ: μέγιστη φόρτιση (peak): mmHg

ΑΠ: αποκατάσταση (recovery): mmHg

HR: ηρεμία (rest): bpm

HR: μέγιστη φόρτιση (peak): bpm

HR: αποκατάσταση (recovery): bpm

Στη αρχή της φάσης αποκατάστασης (recovery) έγινε έγχυση ενδοφλεβίως mg μετοπρολόλης.

Συνολικό score στην ηρεμία: 17

Συνολικό score στη μέγιστη φόρτιση: 17

Συνολικό score στην αποκατάσταση (recovery): 17

Δείκτης τμηματικής κινητικότητας (WMSI) στην ηρεμία: 1,00

Δείκτης τμηματικής κινητικότητας (WMSI) στη μέγιστη φόρτιση: 1,00

Δείκτης τμηματικής κινητικότητας (WMSI) στην αποκατάσταση (recovery): 1,00

Κλάσμα εξώθησης στην ηρεμία: %

Κλάσμα εξώθησης στην μέγιστη φόρτιση: %

Κλάσμα εξώθησης στην αποκατάσταση: %

- 1) Πρόσθιο τοίχωμα (κορυφαία λήψη 2 κοιλοτήτων) (τμήματα 2,7):
- 2) Πρόσθιο μεσοκοιλιακό (κορυφαία λήψη 3 κοιλοτήτων) (τμήματα 1,6):
- 3) Οπίσθιο μεσοκοιλιακό (κορυφαία λήψη 4 κοιλοτήτων) (τμήματα 5,10):
- 4) Πλάγιο τοίχωμα (κορυφαία λήψη 4 κοιλοτήτων) (τμήματα 3,8):
- 5) Κατώτερο τοίχωμα (κορυφαία λήψη 2 κοιλοτήτων) (τμήματα 4,9):
- 6) Οπισθιο τοίχωμα (κορυφαία λήψη 3 κοιλοτήτων) (τμήματα 15,16):
- 7) Κορυφαία τοίχωματα (τμήματα 11,12,13,14) :

Παρατηρήσεις:

Συμπέρασμα:

Stress echocardiography limitations

1. Depends on image quality (patient habitus / system requirements)
2. Subjective interpretation
3. Interobserver variability
4. Recognition of ischemia within areas of abnormal resting wall motion
5. Influence of LV cavity size
6. Lower diagnostic accuracy of single vessel CAD
7. Recognition of multivessel CAD
8. Follow-up difficult

Myocardial viability estimation (VIABILITY)

Myocardial viability is assessed only in severely dysfunctional segments; 4 types of wall motion responses are observed:

- (1) biphasic pattern: improvement of wall motion at 5, 10, or 20 mg/kg/min dobutamine with worsening at higher dosages
 - (2) worsening
 - (3) sustained improvement
 - (4) no change
- Severely dysfunctional segments exhibiting a biphasic, worsening or sustained response are considered viable, whereas segments with unchanged wall motion are considered scarred.
 - **A patient is considered to have viable myocardium in the presence of ≥ 4 -5 viable segments ($WMSI > 0,25$) and as non-viable in the presence of ≤ 4 viable segments (50% viable myocytes in a given segment)**

*Table : Comparison of sensitivities and specificities of different stress imaging modalities in detecting CAD (table 1A) or myocardial viability (table 1B).
Concluding results from meta-analyses.

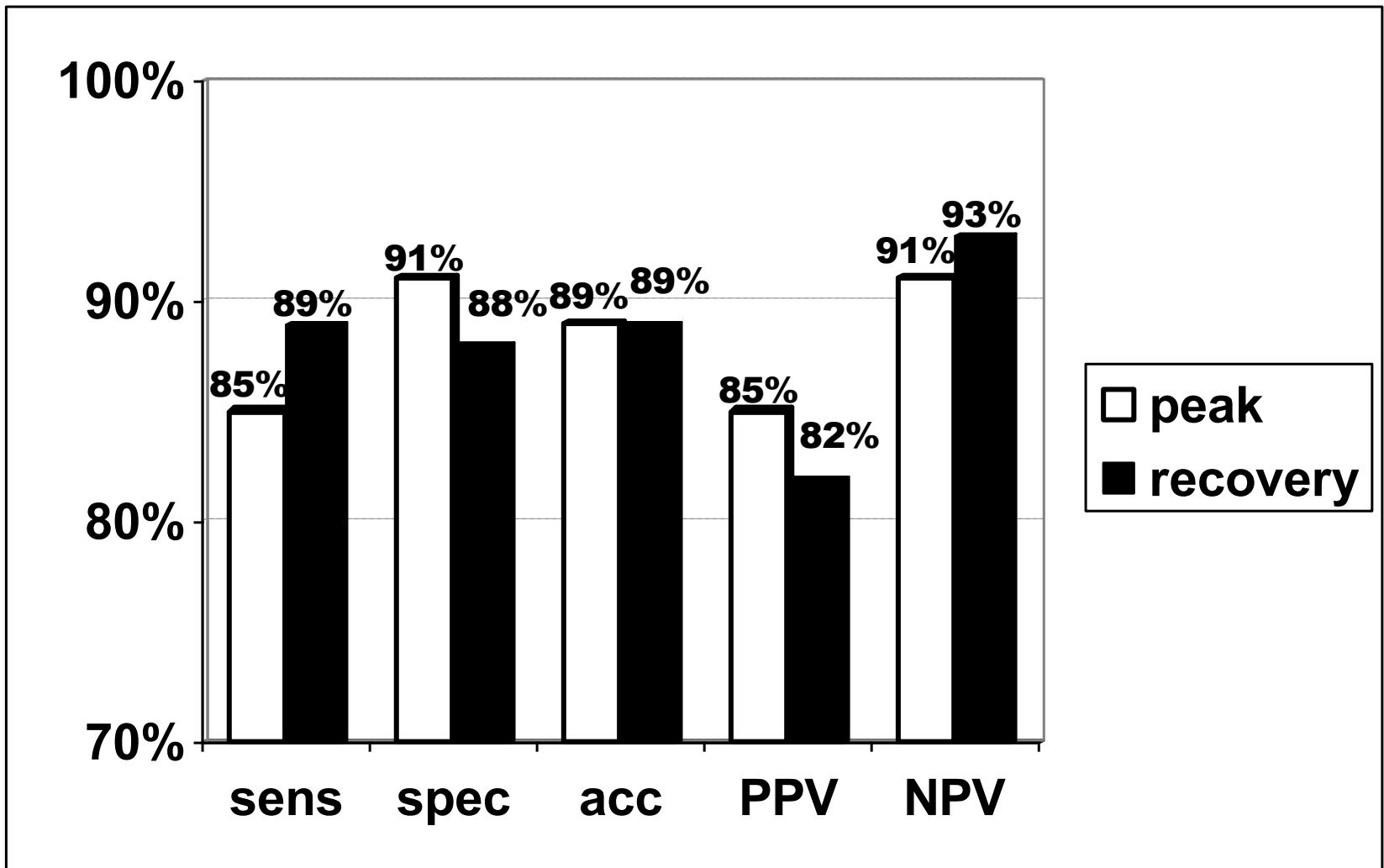
Table 1A		Ischemia detection			
	DSE	SPECT	MRI	PET	
Sensitivity	80-85%	83-95%	84-91%	93%	
Specificity	87-92%	73%	80%	82%	

Table 1B		Viability Estimation			
	DSE	SPECT	MRI	PET	
Sensitivity	84-86%	84%	96%	100%	
Specificity	81-90%	54-69%	86-100%	90%	

[Circ Cardiovasc Imaging](#). 2017 Nov;10(11). 10.1161/CIRCIMAGING.117.006530

[Cardiovasc Ultrasound](#). 2017 Mar 21;15(1):7. doi: 10.1186/s12947-017-0099-2

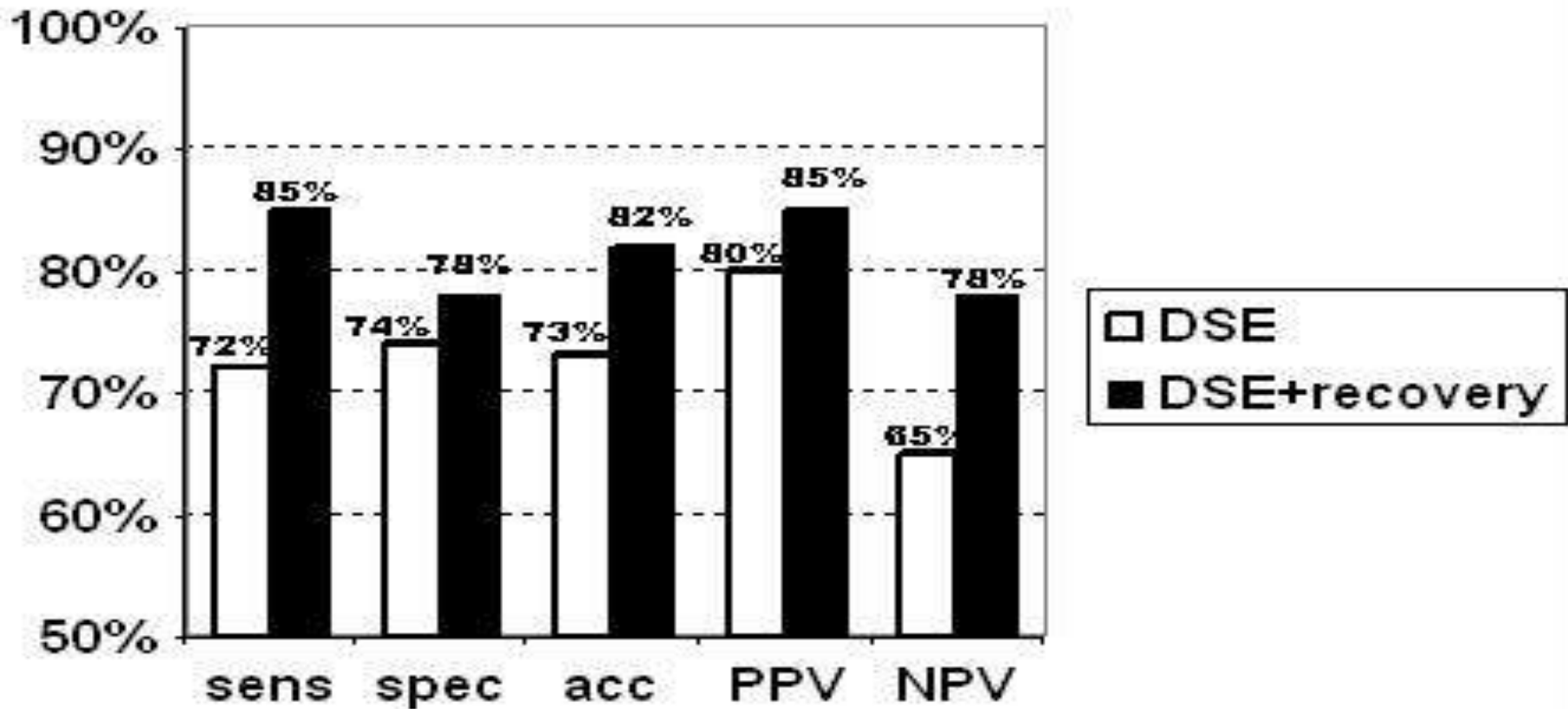
[European Society of Cardiology. Eur Heart J](#). 2013;34:2949–3003 Task Force on the management of stable coronary artery disease



Enhanced Sensitivity of Dobutamine Stress Echocardiography by Observing Wall Motion Abnormalities During the Recovery Phase After Acute Beta Blocker Administration.

S.E. Karagiannis, J. J. Bax, A. Elhendy, et al.

Am J Cardiol. 2006 Feb 15;97(4):462-5



Myocardial viability estimation during recovery phase of stress echocardiography after acute beta-blocker administration

Stefanos E. Karagiannis, Harm H.H. Feringa, Jeroen J. Bax, et al (**Eur Journal Heart Failure April 2007** Volume 9, Issue 4 Pages 325–436)

Dobutamine stress echocardiography for the detection of myocardial viability in patients with left ventricular dysfunction taking β blockers: accuracy and optimal dose

T Zaglavara, R Haaverstad, B Cumberledge, T Irvine, H Karvounis, G Parharidis, G Louridas and A Kenny

Heart 2002;87;329-335

B-blocker withdrawal is not necessary before DSE when viability is the clinical information in question. However, a completed protocol with continuous image recording is required to detect the full extent of viability.

Prognostic Value of Myocardial Viability in Medically Treated Patients With Global Left Ventricular Dysfunction Early After an Acute Uncomplicated Myocardial Infarction : A Dobutamine Stress Echocardiographic Study

Eugenio Picano, Rosa Sicari, Patrizia Landi, Lauro Cortigiani, Riccardo Bigi, Claudio Coletta, Alfonso Galati, Joanna Heyman, Roberto Mattioli, Mario Previtali, Wilson Mathias, Jr, Claudio Dodi, Giovanni Minardi, Jorge Lowenstein, Giovanni Seveso, Alessandro Pingitore, Alessandro Salustri and Mauro Raciti
Circulation 1998;98:1078-1084

In medically treated patients with severe global left ventricular dysfunction early after acute uncomplicated myocardial infarction, the presence of myocardial viability identified as inotropic reserve after low-dose dobutamine is associated with a higher probability of survival. The higher the number of segments showing improvement of function, the better the impact is of myocardial viability on survival. The presence of inducible ischemia in this set of patients is the best predictor of cardiac death.

Myocardial viability assessed by dobutamine stress echocardiography predicts reduced mortality early after acute myocardial infarction: determining the risk of events after myocardial infarction (DREAM) study

J M A Swinburn and R Senior

Heart 2006;92;44-48; originally published online 14 Apr 2005;

PROGNOSTIC VALUE OF DOBUTAMINE STRESS ECHOCARDIOGRAPHY IN PATIENTS WITH CHRONIC KIDNEY DISEASE

J Am Soc Nephrol 14: 3233–3238, 2003

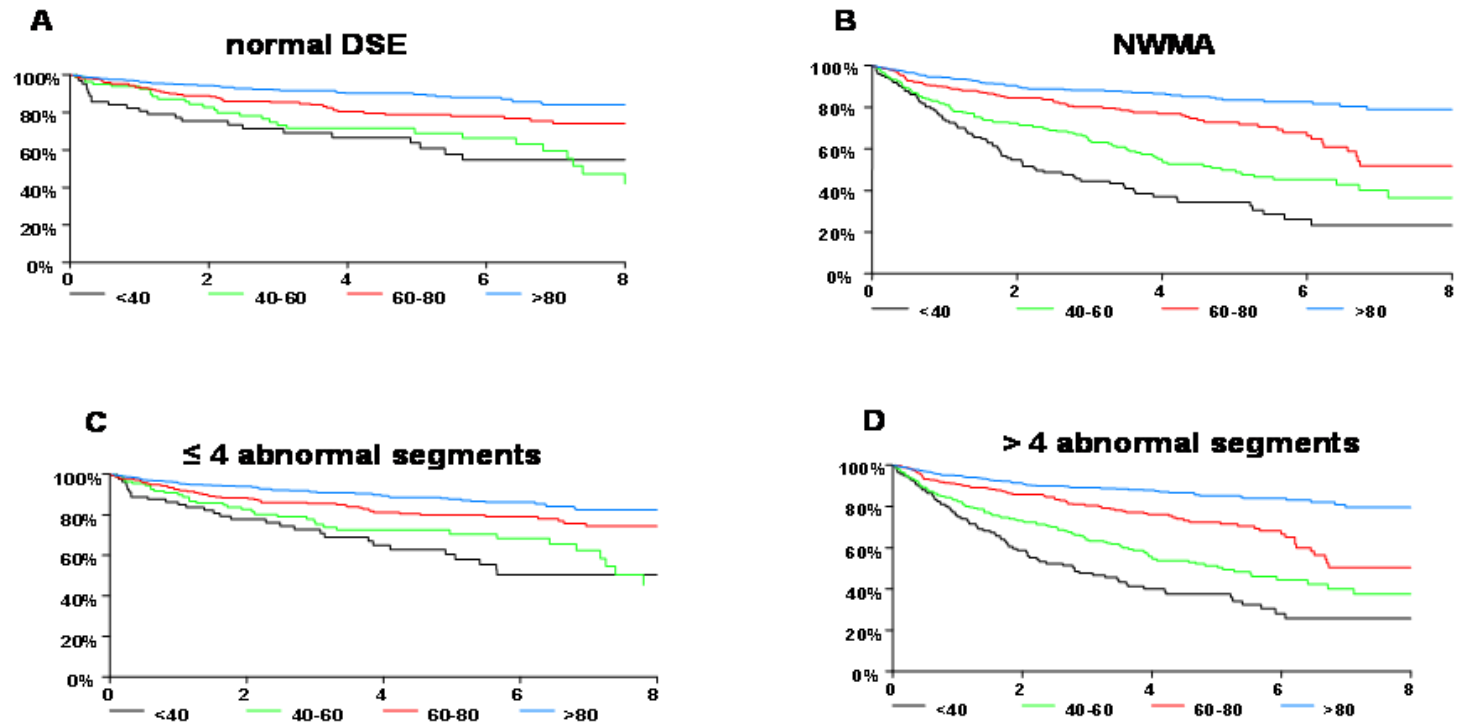
Association between Renal Insufficiency and Inducible Ischemia in Patients with Coronary Artery Disease: The Heart and Soul Study

JOACHIM H. IX,* MICHAEL G. SHLIPAK,*†‡ HAIYING H. LIU,†
NELSON B. SCHILLER,*§ and MARY A. WHOOLEY*†‡

**Department of Medicine, University of California, San Francisco, San Francisco, California; †Section of General Internal Medicine, VA Medical Center, San Francisco, California; ‡Department of Epidemiology and Biostatistics, University of California, San Francisco, San Francisco, California; and §Division of Cardiology, University of California, San Francisco, San Francisco, California*

CRI is strongly associated with exercise-induced ischemia in patients with CAD. The greater severity of atherosclerotic disease observed in patients with CRI may in part explain the association of CRI with increased cardiovascular risk among individuals with CAD.

All cause mortality in patients undergoing DSE according to creatinine clearance



Prognostic significance of renal function in patients undergoing dobutamine stress echocardiography

Stefanos E. Karagiannis¹ MD, Harm H.H. Feringa¹ MD, et al:

Nephrology Dialysis Transplantation, Volume 23, Issue 2, 1 February 2008, Pages 601–607

Dobutamine Stress Echocardiography in Patients With Diabetes Mellitus

Enhanced Prognostic Prediction Using a Simple Risk Score

Nithima Chaowalit, MD, Ana Lucia Arruda, MD, Robert B. McCully, MD, FACC, Kent R. Bailey, PhD,
Patricia A. Pellikka, MD, FACC

Rochester, Minnesota

- OBJECTIVES** We sought to determine the prognostic value of dobutamine stress echocardiography (DSE) for predicting long-term outcomes in a large cohort with diabetes mellitus and to develop a simple risk score using clinical and echocardiographic data.
- BACKGROUND** Neither risk scores nor long-term prognostic value of DSE has been described in a large diabetic population.
- METHODS** We studied 2,349 patients with diabetes mellitus (1,338 men, 67 ± 11 years of age) during a follow-up of 5.4 ± 2.2 years.
- RESULTS** Mortality and morbidity (myocardial infarction and late coronary revascularization) occurred in 1,044 (44%) and 309 (13%) patients, respectively. Addition of stress echocardiographic variables to the clinical and rest echocardiographic model provided incremental prognostic information for predicting mortality (chi-square = 243 to 270, $p < 0.0001$) and morbidity (chi-square = 38 to 78, $p < 0.0001$). For each end point, a simple risk score was derived according to the estimated values of beta coefficients of multivariate predictors (insulin therapy, smoking, failure to achieve target heart rate, percentage of ischemic segments, and impaired left ventricular systolic function) and resulted in an assessment of risk among all age groups. The C-statistic values were 0.60 to 0.64, indicating modest discrimination. The estimated five-year event-free survivals of patients in three risk categories were 94%, 86%, and 80% for morbidity ($p < 0.00001$) and 69%, 60%, and 47% for mortality ($p < 0.0001$).
- CONCLUSIONS** In patients with diabetes mellitus, a simple and practical risk score using clinical variables and results of DSE stratified patients into three risk groups for mortality and cardiovascular morbidity. (J Am Coll Cardiol 2006;47:1029–36) © 2006 by the American College of Cardiology Foundation
-

Perioperative risk assessment for non cardiac vascular surgery

2014 ESC/ESA guidelines on non-cardiac surgery: cardiovascular assessment and management: the Joint Task Force on non-cardiac surgery: cardiovascular assessment and management of the European Society of Cardiology (ESC) and the European Society of Anaesthesiology (ESA). **Eur Heart J. 2014;35:2383–431.**

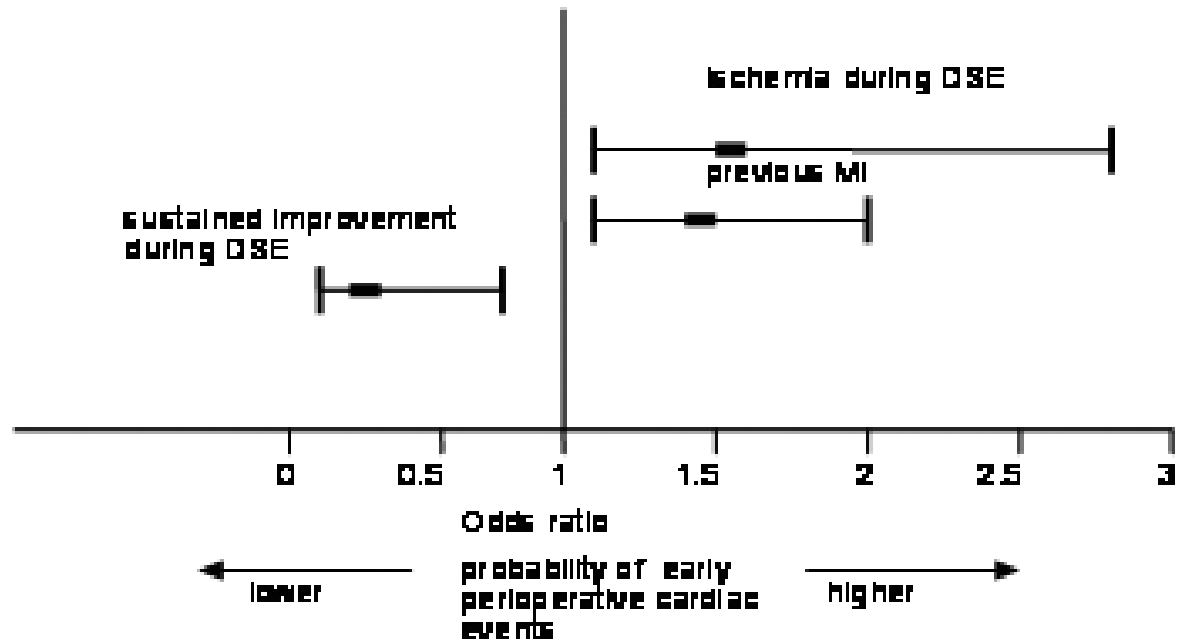
In pts with more than two clinical risk factors and poor functional capacity (Class I, Evidence C)

2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines. **J Am Coll Cardiol. 2014;64:e77–137**

Perioperative Cardiac Assessment for Noncardiac Surgery: Eight Steps to the Best Possible Outcome

Debabrata Mukherjee and Kim A. Eagle
***Circulation* 2003;107;2771-2774**

A meta-analysis comparing the prognostic accuracy of six diagnostic tests for **predicting perioperative cardiac risk in patients undergoing major vascular surgery**. Kertai MD, Boersma E, Bax JJ, et al
Heart. 2003;89:1327–34.



DSE: Dobutamine Stress Echocardiography

MI: Myocardial Infarction

Karagiannis SE, Feringa HH, Vidakovic R, et al. Value of myocardial viability estimation using dobutamine stress echocardiography in assessing risk preoperatively before noncardiac vascular surgery in patients with left ventricular ejection fraction < 35%.

Am J Cardiol. 2007;99:1555–9.

Stress echocardiography for the diagnosis of coronary artery disease: progress towards quantification

Patricia A. Pellikka

Curr Opin Cardiol 20:395—398. 2005

Automated coupled-contour and robust myocardium tracking in stress echocardiography

Stefanos E. Karagiannis, Jos Roelandt et al

European Journal of Echocardiography, Volume 8, Issue 6, 1 December 2007

REVIEW PAPER

Quantitative Techniques for Stress Echocardiography: Dream or Reality?

T. H. Marwick

University of Queensland, Australia

Stress echocardiography is now an everyday clinical tool. However, the substantial evidence base that supports its use is largely derived from expert centres, and concerns have been expressed about the performance of the test in less expert hands. A unifying feature of the problems of stress echocardiography is its subjective assessment. This review examines the consequences of qualitative interpretation and the benefits of developing a quantitative approach. Although no quantitative approach is in widespread clinical

use, several alternative techniques are feasible, and this area warrants further study.

(*Eur J Echocardiography* 2002; 3: 171–176)

© 2002 Published by Elsevier Science Ltd on behalf of The European Society of Cardiology

Key Words: stress echocardiography; interpretation; quantitation.

The myth'' of the false positive stress echo. [Labovitz AJ.](#)

J Am Soc Echocardiogr. 2010 Feb;23(2):207-14.

Characteristics and outcomes of patients with abnormal stress echocardiograms and angiographically mild coronary artery disease (<50% stenoses) or normal coronary arteries.

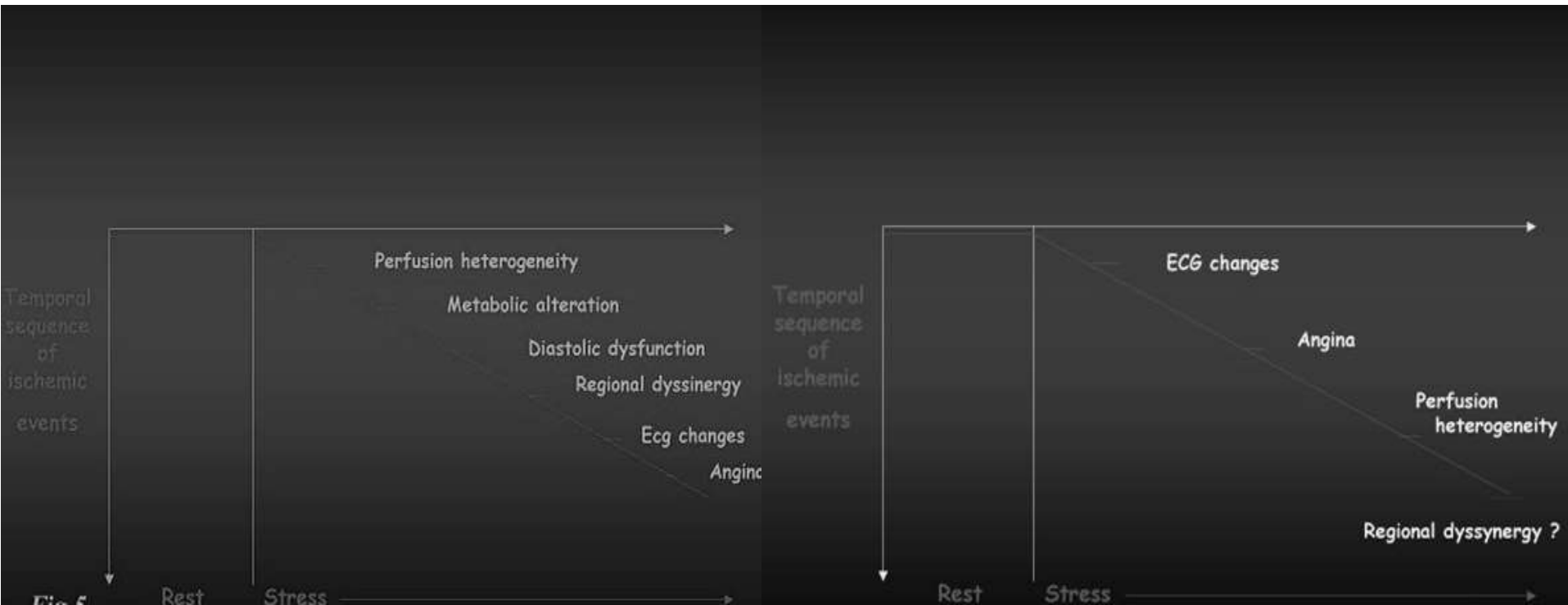
From AM, [Kane G](#), [Bruce C](#), [Pellikka PA](#), [Scott C](#), [McCully RB](#).

Echocardiography Laboratory, Division of Cardiovascular Diseases, Department of Internal Medicine, Mayo Clinic, Rochester, Minnesota 55905, USA.

•[J Am Soc Echocardiogr. 2010 Feb;23\(2\):215-6.](#)

BACKGROUND: Abnormal cardiac stress imaging findings are not always associated with angiographically significant coronary artery disease. The outcomes of patients with such false-positive findings have not been extensively examined. The aim of this retrospective study was to describe the characteristics and outcomes of patients with abnormal stress echocardiographic findings who had false-positive results compared with those who had true-positive results. **METHODS:** Of 1,477 consecutive patients (mean age, 66 +/- 12 years; 61% men) with abnormal stress echocardiographic findings who underwent coronary arteriography within 30 days, death from any cause was ascertained. **RESULTS:** At coronary arteriography, 997 patients (67.5%) had true-positive results, defined by the presence of angiographically significant coronary artery disease (> or = 50% stenoses), and 480 (32.5%) had false-positive results, defined by <50% stenoses or normal coronary arteries. Of the subgroup of patients with markedly abnormal stress echocardiographic findings (n = 605), 28% had <50% stenoses or normal coronary arteries. During an average follow-up period of 2.4 +/- 1.0 years, there were 140 deaths. The adjusted likelihood of subsequent death for patients with <50% stenoses compared to patients with > or = 50% stenoses after abnormal stress echocardiography was 1.05 (95% confidence interval, 0.86-1.31; P = .62). **CONCLUSIONS:** A sizable proportion of patients with abnormal stress echocardiographic results who are referred for coronary angiography have false-positive findings. **The outcomes of patients with false-positive results were similar to those of patients with true-positive results.** ***This finding suggests that patients with false-positive results on stress echocardiography should still receive intensive risk factor management and careful clinical follow-up.***

Ischemic Cascade



Classical

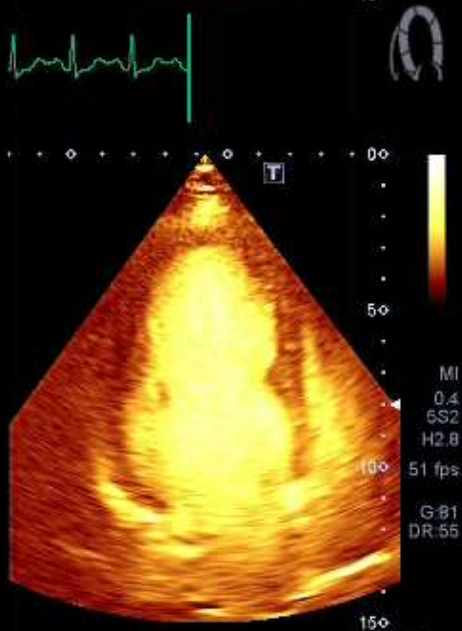
Alternative

Rest
4Ch
00:09
113 bpm



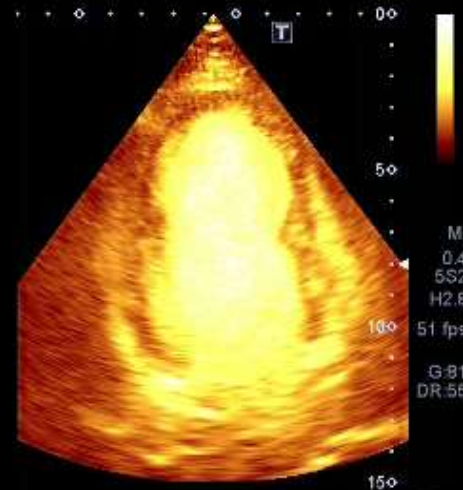
10:20:36 am

Peak
4Ch
00:09
120 bpm



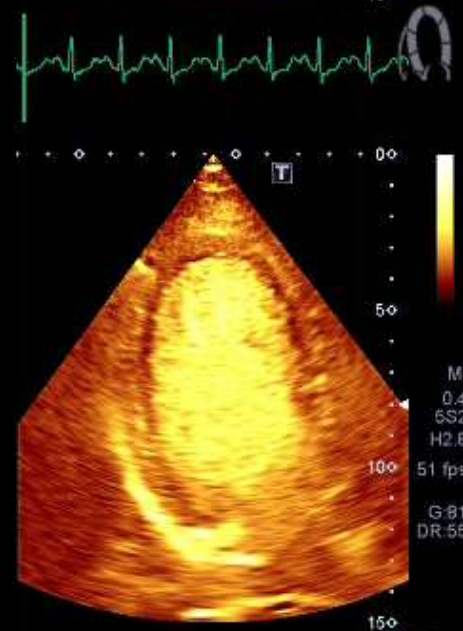
10:21:42 am

Low
4Ch
00:09
137 bpm



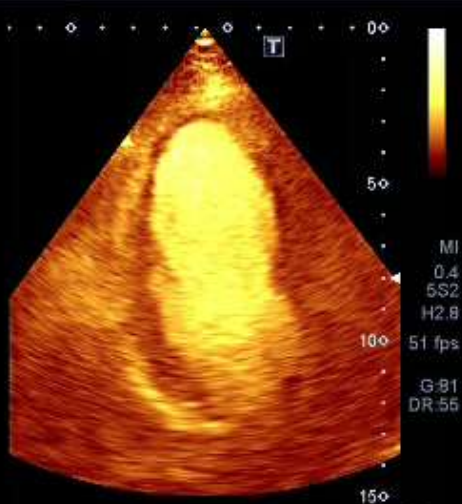
10:21:10 am

Recovery
4Ch
00:10
95 bpm

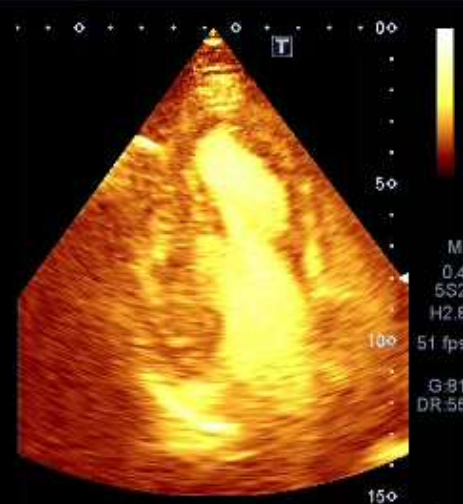


10:22:57 am

Rest
3Ch
00:15
117 bpm

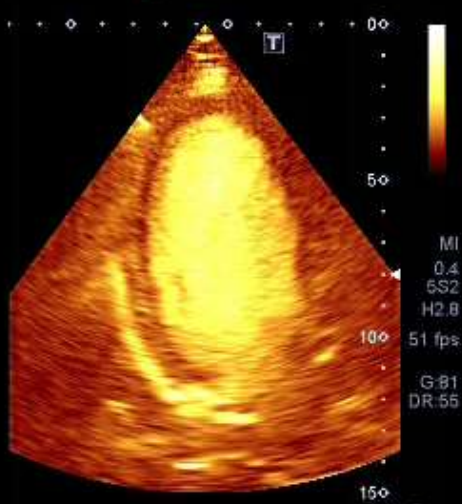


Low
3Ch
00:18
132 bpm



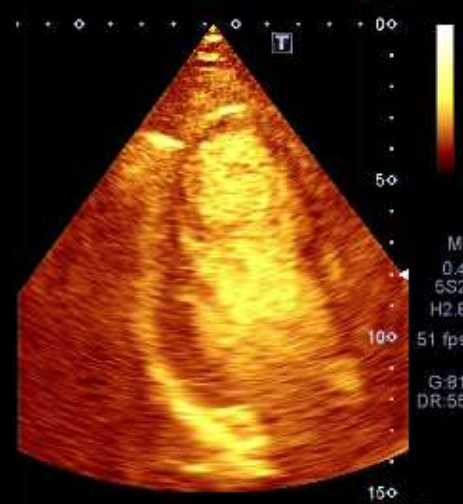
10:20:42 am

Peak
3Ch
00:20
113 bpm



10:21:18 am

Recovery
3Ch
00:19
96 bpm



10:21:53 am

10:23:06 am

