Ischemic heart disease and early diagnosis. Study on the predictive value of 2D strain

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A B S T R A C T

Introduction: Two-dimensional strain echocardiography (2D-SE) quantifies left ventricular global longitudinal strain (GLS) and global circumferential strain (GCS). Our aim was to test 2D-SE during dipyridamole stress echocardiography (Dipy-Stress) in patients with non-diagnostic result, checking by way of coronary CT angiography (CCTA) the possible presence of coronary artery disease (CAD).
Methods: Over twenty-four months 65 consecutive patients with non-diagnostic Dipy-Stress were studied by 2D-SE and by CCTA. GCS and GLS at rest and after stress were compared according to data derived from CCTA.
CAD was graded as significant (stenosis ≥50%), mild (stenosis between 15 and 50%) or absent (stenosis <15%). CCTA was defined as "positive" in presence of mild CAD and "negative" in absence of stenoses. Furthermore, Δ strain was defined as follows: $[(stressS - restS) / restS] \times 100$.
Results: GCS at rest and after stress was similar in CCTA-positive ($26 \pm 5\%$ and $27 \pm 5\%$ respectively) and CCTA-negative groups ($27 \pm 3\%$ and $28 \pm 3\%$ respectively). GLS at rest was significantly reduced ($P < 0.0001$) in CCTA-positive ($23 \pm 3\%$) compared to CCTA-negative group ($25 \pm 2\%$). GLS after stress was lower ($P < 0.0001$) in CCTA-positive group ($20 \pm 3\%$) than CCTA-negative one ($26 \pm 2\%$).
A significant reduction ($P < 0.0001$) of GLS at rest versus after stress was found in positive-CCTA group. ΔGLS showed a significant decrease ($P < 0.0001$) in CCTA-positive ($-10 \pm 8\%$) compared to CCTA-negative ($4.4 \pm 5.8\%$) group.
ROC analysis of ΔGLS showed high accuracy (area under the ROC curve 0.916, 95% CI: 0.820–0.970) in distinguishing positive and negative CCTA groups.
Conclusions: 2D-SE during Dipy-Stress allows, in case of non-diagnostic test, identification of mild-CAD with high sensitivity and specificity.

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1. Introduction

Ischemic heart disease is a major cause of death with a growing clinical and economic impact [1].

An early identification of coronary artery disease (CAD) and its correction by appropriate medical treatment and/or coronary revascularization reduces the incidence of cardiac events and improve the prognosis [2].

A non-invasive provocative test is generally required for the detection of myocardial ischemia in patients with multiple cardiovascular risk factors but also in those ones without history of ischemic heart disease or left ventricle (LV) dysfunction [3,4]. Dipyridamole stress echocardiography (Dipy-Stress) is a test widely recognized to unmask

CAD in patients with moderate cardiovascular risk. Particularly Dipy-Stress has an excellent negative predictive value [5–7].

Recently two-dimensional strain echocardiography (2D-SE) has been introduced as a valid method to quantify both left ventricular (LV) longitudinal (L) and circumferential (C) deformation [8–16].

An early impairment of LV deformation, often without clinical signs of disease, has been observed in many heart diseases [17].

2D-SE is able to detect even minimal abnormalities of systolic function [15,16] improving the ability to quantitatively assess regional LV function [18].

Coronary CT angiography (CCTA) is a non-invasive diagnostic procedure for the direct identification of significant (≥50%) and not significant (<50%) coronary stenoses [19–24].

Previous studies investigated the clinical value of stress echocardiography to detect abnormalities of LV deformation due to significant CAD [25–27]. No previous studies instead investigated if mild coronary stenoses (<50%) could have an effect on LV deformation.

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The aim of our study was to test the usefulness of 2D-SE during Dipy-Stress in a group of patients with a non-diagnostic test result (no wall motion abnormalities or significant electrocardiographic changes in presence of atypical symptoms), checking through CCTA the presence of CAD Fig. 1.

2. Methods

2.1. Study population

Over twenty-four months we enrolled 71 consecutive patients [60 ± 6 years old, 34 (48%) female] with: 1) atypical chest pain, 2) no previous heart diseases, 3) no mechanical alterations during Dipy-Stress (wall motion score index, WMSI = 1) and 4) no electrocardiographic alterations during and after Dipy-Stress [28]. Baseline characteristics and cardiovascular risk factors as age, gender, estrogen status, diabetes mellitus, hypercholesterolemia, obesity, current or prior cigarette smoking, arterial hypertension, and a positive family history of CAD were collected before Dipy-Stress examination. According to these cardiovascular risk factors a Morise score [29] was quantified for each patient. Clinical characteristics are summarized in Table 1.

Everyone was then studied by 2D strain echocardiography "off-line" and by coronary CT angiography. Patients presenting with a) abnormal wall motion during stress echocardiography, b) kinetic abnormalities due to left bundle branch block and/or pacemaker stimulation, c) ejection fraction inferior to 50% at rest, or d) chronic coronary artery disease, arrhythmias, previous cardiac surgery, cardiomyopathies or moderate to severe valve disorders were excluded from the study (Fig. 1). Our local ethics committee reviewed the study and approved the investigation, judging it compliant to the principles outlined in the Helsinki Declaration. Written informed consent was obtained from all the subjects.

Table 1
Study population (clinical characteristics).

Variable	All patients (n = 65)
Age (years)	60 ± 6
Male	37
BMI (kg/m^2)	27 ± 3
SBP (mm Hg)	130 ± 16
DBP (mm Hg)	85 ± 11
HR (beats/min)	76 ± 13
Coronary risk factors (%)	
Arterial hypertension	74
Smoke	55
Hypercholesterolemia	58
Family history of cardiovascular disease	46
Diabetes mellitus	46
CRF	6
Morise score	15 ± 2
Drugs (%)	
ACE inhibitors/ARB	65
β-Blockers	46
Calcium antagonists	23
Diuretics	31
Aspirin	58
Statins	58
Insulin therapy	3
Oral hypoglycemic agents	43

BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate; CRF = chronic renal failure; Morise score = clinical score to estimate the probability of coronary artery disease; ACE = angiotensin-converting enzyme; ARB = angiotensin receptor blocker.

2.2. Echocardiography data acquisition

Two-dimensional echocardiographic images were acquired using an ultrasound equipment (My Lab ALFA, Esaote, Florence, Italy) with a 2.5-

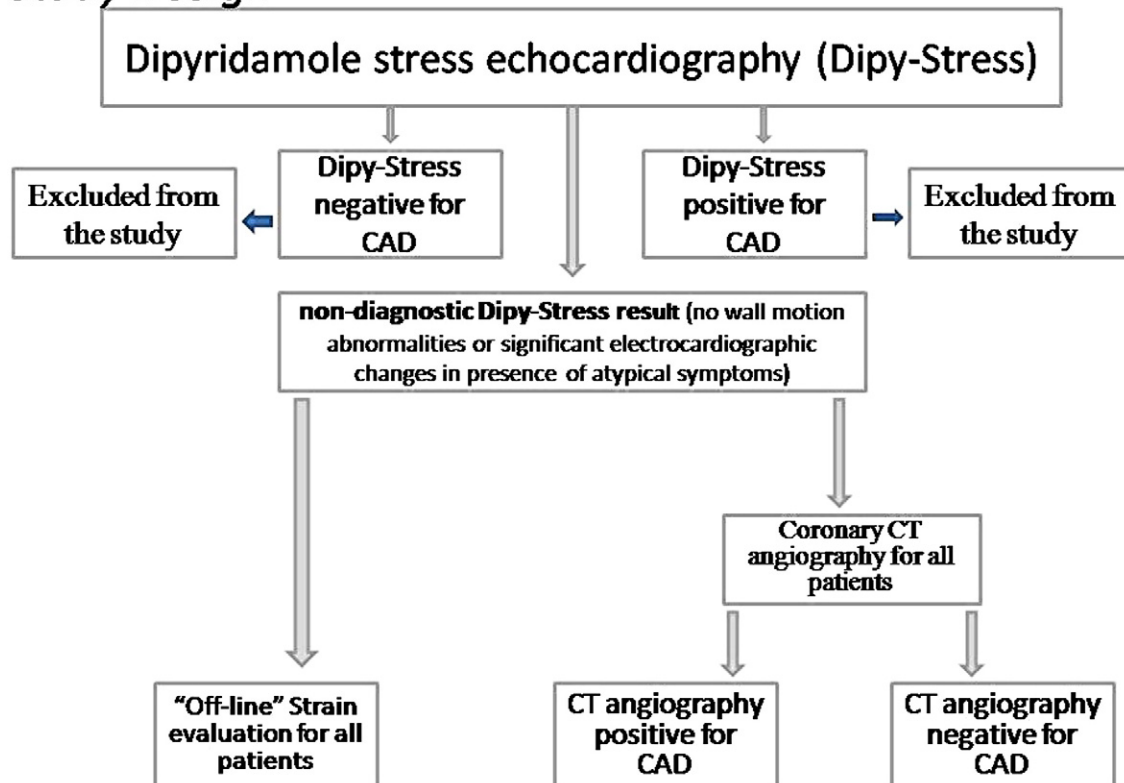Fig. 1. Study design.