CARDIOLOGIE TUNISIENNE

ARTICLE ORIGINAL

Diagnostic accuracy of the stress echocardiography in the assessment of ischemic heart disease

Valeur diagnostique de l'échocardiographie de stress dans l'évaluation des cardiopathies ischémiques

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Summary

Introduction : Chronic Coronary Syndrome (CCS) is a prevalent and impactful global health concern. It encompasses both epicardial coronary artery disease and angina with non-obstructive coronary arteries (ANOCA) or ischemia with non-obstructive coronary arteries (INOCA). Non-obstructive coronary artery disease (CAD) manifests in approximately 50% of patients presenting chest pain with demonstrable myocardial ischemia.

Objective: This study aims to evaluate the sensitivity, and specificity of stress echocardiography in patients with stable coronary artery disease in comparison to coronary angiography.

Methods: We conducted a retrospective and descriptive study including patients with stable coronary artery disease who underwent stress echocardiography and coronary angiography between 2008 and 2022 at Habib Thameur Hospital.

Results: A total of 211 patients were included, with a mean age of 61 ± 10 years, and a male predominance (52.6%). Common cardiovascular risk factors included hypertension (45%) and diabetes mellitus (40%). Stress echocardiography, primarily utilizing dobutamine, identified myocardial ischemia in 41% of cases. Coronary angiography confirmed normal findings in 61.1% of patients, single-vessel disease in 21%, and multiple-vessel disease in 12%. Stress echocardiography demonstrated high sensitivity (86%) and specificity (82%). Positive and negative predictive values were 80% and 90%, respectively.

Conclusion: This study underscores the effectiveness of stress echocardiography, in detecting myocardial ischemia among patients with stable coronary artery disease.

Keywords

Stress echocardiography; ischemia; chronic coronary syndrome

Résumé

Introduction : Le syndrome coronarien chronique (SCC) est un problème de santé mondial répandu et avec un impact important. Il englobe à la fois la coronaropathie épicardique et l'angor avec artères coronaires non obstructives ou l'ischémie avec artères coronaires non obstructives. La maladie coronarienne non obstructive se manifeste chez environ 50 % des patients présentant des douleurs thoraciques avec une ischémie myocardique démontrable.

Objectif : Cette étude était d'évaluer la sensibilité et la spécificité de l'échocardiographie de stress chez les patients atteints d'une maladie coronarienne stable par rapport à la coronarographie.

Méthodes : Nous avons mené une étude rétrospective et descriptive incluant des patients atteints d'une maladie coronarienne stable ayant eu une échocardiographie de stress et une coronarographie entre 2008 et 2022 à l'hôpital Habib Thameur.

Résultats : Au total, 211 patients ont été inclus, avec un âge moyen de 61 ± 10 ans et une prédominance masculine (52,6 %). Les facteurs de risque cardiovasculaire comprenaient l'hypertension (45 %) et le diabète sucré (40 %). L'échocardiographie d'effort, utilisant principalement la dobutamine, a identifié une ischémie myocardique dans 41 % des cas. L'angiographie coronarienne a confirmé des résultats normaux chez 61,1 % des patients, une maladie monotronculaire chez 21 % et une maladie multitronculaire chez 12 %. L'échocardiographie de stress a démontré une sensibilité (86 %) et une spécificité (82 %) élevées. Les valeurs prédictives positives et négatives étaient respectivement de 80 % et 90 %.

Conclusion : Cette étude souligne l'importance de l'échocardiographie de stress pour détecter l'ischémie myocardique chez les patients atteints d'une maladie coronarienne stable.

Mots-clés

Echographie de stress; ischemie; syndrome coronaire chronique

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INTRODUCTION

Chronic coronary syndrome (CCS) is the most common chronic cardiovascular disease and the leading cause of death in developed countries (1). It is subdivided into two physio-pathological entities: epicardial coronary artery disease and angina with non-obstructive coronary arteries (ANOCA) or ischemia with non-obstructive coronary arteries (INOCA) when there is evidence of ischemia by ECG or a cardiac imaging study (2). Approximately 50% of patients with chest pain and objective evidence of myocardial ischemia are found to have non-obstructive coronary artery disease (CAD) on angiography (3).

Stress echocardiography is the non-invasive method of choice for the assessment of coronary artery disease (CAD). Its use has increased exponentially as a reliable and cost-effective method for both the diagnosis and risk stratification of patients with suspected or known CAD. (4)

It is a powerful functional test to detect inducible ischemia predominantly by assessing regional wall motion abnormality (RWMA), which is a sensitive and specific marker of significant epicardial obstructive CAD but it is unable to detect non-obstructive coronary plaque. The integration of diastolic function, ECG changes, and indices of global LV function has a higher potential to capture the whole spectrum of ischemia phenotypes. (2)

Our study aims to evaluate the sensitivity, and specificity of stress echocardiography in patients with stable coronary artery disease in comparison to coronary angiography.

METHODS

We conducted a retrospective and descriptive study that included patients with stable coronary artery disease who underwent stress echocardiography and coronary angiography performed between 2008 and 2022 in the cardiology department of Habib Thameur Hospital.

We included patients with chronic coronary syndrome with no cardiovascular history who underwent stress echocardiography and coronary angiography in the same year. Patients who underwent stress echocardiography for other indications were not included.

Patients who didn't reach the maximal theoric rate heart, with poor acoustic window, didn't undergo a coronary angiography or underwent coronary angiography after one year were excluded.

The following data were collected from hospital records or outpatient consultations:

Clinical data: age, gender, cardiovascular risk factors, symptoms.

Electrocardiogram (EKG): abnormal pattern – Left bundle branch block (LBBB)

Echocardiographic data: baseline heart rate, maximum theoretical heart rate (MTHR), symptoms, electrical changes, segmental kinetics, results.

For dobutamine stress echocardiograms: dobutamine dose, atropine administration.

Coronary angiography: normal, one vessel or multiple vessel lesions.

1. Stress Echocardiography

Transthoracic echocardiograms (ETT) were performed by three qualified operators, with the assistance of a nurse, using an ALT HDI 5000 ultrasound machine between 2008 and 2012. Starting in 2013, a VividE9 device (General Electric Vingmed Ultrasound Medical System) equipped with a 3.5 MHz probe was used.

The examination room was equipped with resuscitation equipment.

During the examination, patients underwent clinical monitoring of blood pressure, rhythm, and heart rate through continuous monitoring.

A 12-lead ECG was conducted at each stage and in cases of clinical or rhythmic events.

Exercise Stress Echocardiography

A tilting table with pedals was employed. The stage duration was 2 minutes, with a gradual increase in the workload of 20 to 25 watts. (5)

Dobutamine Stress Echocardiography

Perfusion was achieved through a peripheral vein, administered continuously using an electric syringe pump for dobutamine and as a bolus for atropine.

Dobutamine was administered at increasing doses of 5 gamma/kg/minute in 3-minute stages. In the absence of stopping criteria, dobutamine infusion continued until reaching a dose of 40 gamma/kg/minute.

The objective was to achieve at least 85% of the maximum theoretical heart rate (MTHR), which is 220 minus the patient's age, or another stopping criterion.

In the absence of a chronotropic response, increasing doses of atropine from 0.25 mg to 1 mg (in the absence of contraindications) were administered, typically initiated at the 40 gamma/kg/minute stage.

During the course of the examination, patients were monitored with blood pressure measurements taken every 3 minutes. At each stage, the left ventricular kinetics were recorded in multiple views, with a comparison to the resting sequence displayed on a split-screen with four quadrants.

At the end of the examination or in the event of an immediate need to terminate it, a beta-blocker was administered (typically Atenolol at a dosage of 1.25 to 5 mg) in the absence of contraindications (5).

2. Positivity Criteria

Clinical Criteria

Positivity criteria included the occurrence of chest pain suggestive of angina during the examination or signs of poor tolerance to exertion.

Electrocardiographic Criteria

Positivity criteria were defined as follows:

Horizontal or descending ST-segment sub-depression of 2mm or more in at least two concordant leads.

ST-segment elevation of more than 2mm in at least 2 concordant leads.

Echocardiographic Criteria

The appearance of abnormalities in segmental kinetics under high doses of dobutamine in at least two contiguous segments was considered a positivity criterion.

The presence of a biphasic response, indicating both viability and ischemia, characterized by an improvement in kinetics at low dobutamine doses followed by its deterioration at high dobutamine doses, was considered a positivity criterion (5).

3. Stress echocardiographic stopping criteria: The criteria were as follows

Severe segmental kinetic abnormalities: akinesia involving at least 2 segments.

Anginal chest pain.

Electrocardiographic changes are suggestive of ischemia.

High blood pressure with a systolic blood pressure (SBP) greater than 250 mmHg and/or diastolic blood pressure (DBP) greater than 120 mmHg.

Symptomatic hypotension or a drop greater than 40 mmHg.

Onset of life-threatening supraventricular or ventricular rhythm disturbances.

Achievement of the maximum theoretical heart rate (MTHR).

Maximum dose of dobutamine and atropine (5).

4. Invasive coronary angiography

Coronary angiography was conducted using either radial or femoral arterial access, with visual assessment determining the percentage of vessel stenosis. A coronary artery lesion was considered significant if it comprised ≥50% of the luminal diameter. Multivessel coronary artery disease was characterized by the presence of a ≥50% luminal diameter lesion in more than one epicardial coronary artery (6).

5. Statistical Analysis

The data were analyzed using SPSS 26 software.

We calculated simple frequencies and relative frequencies for qualitative variables.

We also computed means, medians, and standard deviations, and determined the range (extreme values) for quantitative variables.

To select the optimal variable value that corresponds to the best sensitivity/specificity pairing, we converted the qualitative variables with multiple modalities into qualitative variables with two modalities and plotted the ROC curves (receiver operating characteristics).

RESULTS

1. Study population

Among all the patients referred for dobutamine stress echocardiography (DSE), 211 were included in the study. The flow chart of the study is shown in the figure 1.

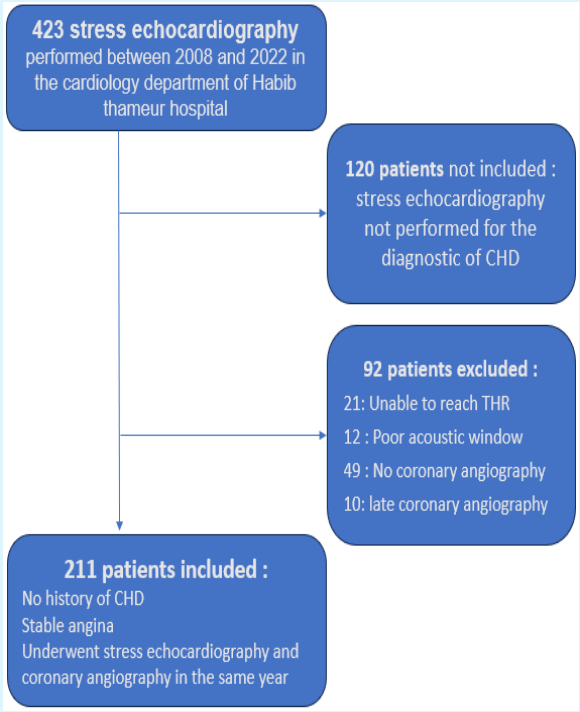

Figure 1. Study flow chart

The mean age was 61 ± 10 years, with extremes ranging from 32 to 89 years. 110 patients were male (52.6%) and 101 female (47.4%), with a gender ratio of 1.1.The baseline characteristics of the population are summarized in Table 1.

Table 1. Baseline characteristics

Patients	N = 211
Mean Age	61 ± 10 years old [32 - 89 years old]
Male	110 (52.6%)
Female	101 (47.4%)
Cardiovascular risk factors	
Hypertension	94 (45%)
Diabetes mellitus	84 (40%)
Dyslipidemia	78 (37%)
Smoking	109 (52%)
Symptoms	
Chest pain	168 (84%)
Dyspnea	42 (19%)
Palpitations	14 (7%)
EKG	
Abnormal pattern	127 (58%)
LBBB	7 (3,3%)
Echocardiographic findings	
LVEF (%)	57% [51% - 64%]
LVEDD (mm)	47.4 mm [43.6 – 53,4mm]

LVEF: Left ventricular ejection fraction; LVEDD: Left ventricle end-diastolic diameter
LBBB: Left bundle branch block

2. Stress echocardiography results

Dobutamine echocardiography was performed in 88.2% (n=185) of cases and exercise echocardiography in 11.8% (n=26). The median interval between stress echocardiography (SE) and invasive coronary angiography was 8 (0 - 13) months. The mean dose of dobutamine infused was 27.5 ±7 gamma/Kg/min ranging from 13 to 35 gamma/Kg/min. Atropine was injected in 81% of cases. Heart rate increased from 70 ± 13 to 138 ± 13 bpm with extremes were respectively between 60 to 93 bpm and from 130 to 155 bpm, and systolic blood pressure (SBP) increased from 131 +/- 20 to 143 +/- 31 mm Hg.

Myocardial ischemia was observed in 41% of cases (based on echocardiographic criteria in 86% of cases). The stress echocardiography was negative in 59% of cases.

Among the 7 patients presenting LBBB in the EKG, 4 patients (60%) had a positive stress echocardiography.

The echocardiographic results of our patients are shown in Table 2.

Table 2. Hemodynamic echocardiographic results

Ischemia positivity Criteria	N = 87
Clinical positive (n, %)	76 (87%)
Electrical positive (n, %)	35 (40%)
Echocardiography positive (n, %)	75 (86%)

3. Coronary angiography results

Coronary angiography confirmed normal findings in 130 patients (61.1%), single vessel disease in 45 patients (21%), and multiple vessel disease in 26 patients (12%).

The results of coronary angiography are shown in the figure below.

Patients with LBBB in the EKG and whose stress echocardiography was positive had lesions in the coronary angiography (figure 1).

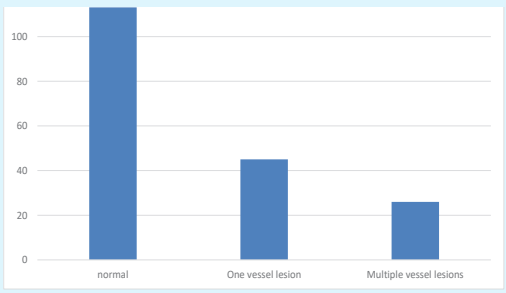

Figure 2. Coronary angiography results

4. Sensitivity and specificity

The study results obtained a high degree of sensitivity (86%), and specificity (82%) of the stress echocardiography as shown below (Figure 2). The positive predictive value (PPV) was 80% and the negative predictive value (NPV) was 90%.

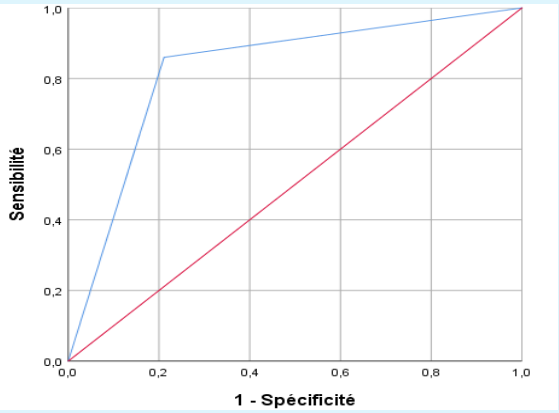

Figure 3. ROC curve of stress echocardiography

DISCUSSION

Our Stress echocardiography (SE) is an adjustable, comfortable non-invasive tool that provides information on the presence, position, and degree of ischemia based on the reaction of regional wall motion to stress.

The aim of our study was to evaluate the sensitivity, and specificity of stress echocardiography in patients with stable coronary artery disease.

We found a high degree of sensitivity (86%), specificity (82%) and accuracy (80%) in our study, demonstrating the importance of this test in assessing chronic coronary disease.

The main limitation of our study is its retrospective, monocentric nature.

Our study protocol didn't include the new four parameters of the stress echocardiography (ABCD) in the assessment of coronary artery disease, which can increase the specificity, sensitivity and accuracy of stress echocardiography.

The main strength of our study is that it is one of the first Tunisian study to evaluate SE in stable coronary artery disease.

1. Study Population

The average age was 61 ± 10 years. This result was consistent with the literature data, which reported an average age of 62 years (7), (8), (9).

The characteristics of our population reflect a population at high cardiovascular risk with the presence of, respectively, hypertension, diabetes mellitus, dyslipidemia, and tobacco in 45%,40%,37%, and 52% of the cases. These results align with prior studies (8), (6), (10).

Left bundle branch block (LBBB) was found in 3.3% of our population study. It makes it impossible to interpret the electrocardiogram for ischemia and therefore a stress imaging technique is necessary for the detection of coronary artery disease (11). Our findings are similar to the literature (10).

The echocardiographic characteristics of our population were normal with a mean left ventricular ejection fraction (LVEF) equal to 57% and a Left ventricle end-diastolic diameter (LVEDD) equal to 47.4 mm, agreeing with the results of prior studies (6), (8), (12).

2. Stress echocardiography: results, sensitivity, specificity, and accuracy

The use of dobutamine and exercise, as stressors, in our study was respectively 88,2% and 11,8% which is superior to the EVAREST study where dobutamine was used in 72,9% and exercise in 26,8% of the cases (10).

In our study, the maximum dose of dobutamine infused for myocardial ischemia research was 27.5 ± 7 gamma/kg/min. It was 40 gamma/kg/min in 19% of cases, which is lower than the literature data reporting a dose of 40 gamma/kg/min in 50% of cases (7), (12). Atropine injection was performed in 81% of examinations, exceeding the values found in the literature, which were 30% (7), (12). This can be explained by an early atropine injection starting at a dose of 30 gamma/kg/min if the target heart rate is not achieved, instead of waiting for the 40 gamma/kg/min threshold.

Studies showed that stress echocardiography was positive for ischemia with a percentage ranging from 54% to 80% (8), (6), (12). In our study, myocardial ischemia was observed in 41% of cases (based on echocardiographic criteria in 86% of cases). Our echocardiographic positivity criterion was the occurrence of segmental kinetic abnormalities (RWMA) which is a sensitive and specific marker of significant epicardial obstructive CAD but it is unable

to detect non-obstructive coronary plaque. Therefore, we notice the emergence of a new protocol ABCD which includes four parameters : 1- regional wall motion abnormalities; 2-B-lines measured by lung ultrasound; 3-left ventricular contractile reserve assessed as the stress/rest ratio of force (systolic arterial pressure by cuff sphygmomanometer/end-systolic volume from 2D); 4- coronary flow velocity reserve on left anterior descending coronary artery (with color-Doppler guided pulsed wave Doppler).(13)

Patients with LBBB had a positive test in 60% of cases and all patients had a lesion in the coronary angiography confirming the fact that LBBB remains a diagnostically challenging entity with a poor prognosis. This result aligns with the literature (11).

The study results obtained a high degree of sensitivity (86%), and specificity (82%) of the stress echocardiography as shown below. The positive predictive value (PPV) was 80% and the negative predictive value (NPV) was 90%. Our results are similar to those reported in previously published studies (14), (15), (16).

Therefore, non-invasive functional imaging for myocardial ischemia such as stress echocardiography or coronary CTA is recommended as the initial test to diagnose coronary artery disease (CAD) in symptomatic patients in whom obstructive CAD cannot be excluded by clinical assessment alone as a recommendation class I, level B in the 2019 ESC guidelines of for the diagnosis and management of the chronic coronary syndrome (17).

False negative results for inducible regional wall motion abnormalities (RMWA) may be explained by the non-obstructive coronary artery disease. In contrast, false positive results can occur due to coronary epicardial or microvascular vasospasm or severe coronary microvascular dysfunction(2).

The sensitivity, specificity and accuracy of the stress echocardiography (SE) can be improved using the ABCD protocol. Large scale effectiveness studies are now in progress in the Stress Echo2020 project using this protocol.

CONCLUSION

Stress echocardiography is the non-invasive method of choice for the assessment of coronary artery disease (CAD). This study underscores the effectiveness of stress echocardiography, especially dobutamine stress echocardiography, in detecting myocardial ischemia among patients with stable coronary artery disease. The observed high sensitivity and specificity position it as a valuable diagnostic tool for risk stratification within this patient population.

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