Simultaneous Analysis of Two-Dimensional Strain, Coronary Flow Reserve and Wall Motion during Dipyridamole Stress Echocardiography. Comparative Outcomes.

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SUMMARY

Background
Dipyridamole stress echo (DSE) is an accepted pharmacological test for the evaluation of patients with ischemic pathology; it is demonstrated that it is an ideal technique to combine the visual information of contractility with coronary flow reserve (CFR), but there is no information regarding the use of 2D-strain (two-dimensional deformation) for the diagnosis of myocardial ischemia, so its evaluation and the comparison of results with other methods for the determination of regional ischemia maybe of singular practical interest.

Objective
To compare, during dipyridamole stress echo (DSE), the results of the visual analysis of wall contractility with the value of CFR of the anterior descending artery (ADA) and with the behaviour of longitudinal 2D-strain in the same area, using myocardial perfusion with simultaneous ^{99}m Tc-sestamibi SPECT as gold standard for the diagnosis of ischemia.

Material and Methods
A total of 41 patients (16 men; mean age 68.5 years) referred for DSE were evaluated. The obtained longitudinal 2D-strain was averaged out in the 9 segments corresponding to the ADA from the three apical views both at rest and during stress, considering ischemia the reduction in deformation or an increase lower than 5%. At the peak effect of 0.84 mg/kg of dipyridamole, wall motion, CFR of the ADA (normal: > 2) were evaluated and ^{99}m Tc-sestamibi for stress SPECT was injected, completing its rest view at 24-48 hours.

Results
A total of 3 patients were excluded, one due to weak signal in the ADA and two due to suboptimal window for 2D-strain. A total of twelve patients with reversible defects with SPECT were considered ischemic patients. There was agreement in the four parameters evaluated in 6 patients with all the studies abnormal and in 23 with all the studies normal. Longitudinal deformation in the ADA area in patients with normal SPECT was of -19.9 (-18, -22) at rest and of -22.5 (-21, -26) in the peak of dipyridamole stress echo (p= 0.0003). In those patients with ischemic SPECT, 2D-strain was of -19.35 (-17, -22) at rest and -20.25 (-13, -21) in the peak of dipyridamole stress echo (p= ns). CFR showed a sensitivity of 66.7% (HF 95% 35.4-88.7) and a specificity of 100% and 2D-strain, a sensitivity of 83.3% (HF 95% 50.9-97) and a specificity of 88.5% (HF 95% 68.7-97).

Conclusions
2D-strain during dipyridamole stress echo resulted in a feasible quantitative method with a similar effectiveness of the one of the CFR and better than the visual analysis of contractility for the diagnosis of ischemia in the ADA area.

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Key words > Echography – Physiological stress – Dipyridamole – Cardiac contractility.

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Abbreviations >

ADA	Anterior descending aorta	**NPV**	Negative predictive value
DSE	Dipyridamole stress echo	**PPV**	Positive predictive value
CFR	Coronary flow reserve	**^{99}m Tc-sestamibi**	Single photon computed tomography with 99m Tc-sestamibi
SPECT	Single photon emission computed tomography		

BACKGROUND

Dipyridamole stress echo (DSE) is an accepted pharmacological test for the evaluation of patients with ischemic pathology. Its specificity is similar to the one of the stress echo with dobutamine, but its sensitivity is lower in a vessel disease. (1-3)

The coronary flow reserve (CFR), the maximum vasodilator capacity of an artery, can be evaluated simultaneously with wall motion during DSE and it is an important additional information, which increases the test's sensitivity; however, its use has not been popularized because many laboratories consider that is difficult to perform and/or to apply (4-8). 2D-strain (two-dimensional deformation), based on the *speckle tracking* method, is an original technique which can determine the regional function by means of the semiautomatic examination of the deformation of the walls of the cardiac chambers. (9-11) The program may identify in the echographic image the natural acoustic markers caused by the interaction of the ultrasound on myocardial fibers, which are followed frame by frame during the cardiac cycle. The programme analyzes and averages out the data on the magnitude and the direction of the markers' (speckles) movement calculating multiple parameters (strain, strain rate, torsion) independently of the incidence angle of the ultrasound, thus it does not use the Doppler effect. Applied to different views, it allows quantifying the longitudinal, radial and circumferential deformation of each myocardial segment.

DSE is an ideal technique to combine the visual information of contractility with the CFR, but there is no information regarding the use of 2D-strain for the diagnosis of myocardial ischemia, so its evaluation and comparison of results with other current methods for the determination of regional ischemia maybe of singular practical interest.

The objective of this study was to compare, during DSE, the results of the visual analysis of wall motion with the value of CFR of the anterior descending artery (ADA) with the behaviour of the longitudinal 2D-strain in the same area, using myocardial perfusion SPECT with ^{99}m Tc-sestamibi as gold standard for the diagnosis of myocardial ischemia.

MATERIAL AND METHODS

Population

Between March and April 2007, a total of 41 patients were prospective and consecutively studied (16 men) between 49 and 84 years (68.5± 10.4 years). The inclusion criteria were the indication of a DSE and the signature of the informed consent after knowing the test methodology, with the detail of the habitual DSE's risks, and the approval of the simultaneous evaluation of ischemia by perfusion with ^{99}m Tc-sestamibi from a single procedure. Exclusion criteria as: contraindication to use dipyridamole, patients with acute coronary syndrome of < 5 days of evolution, hemodynamic instability, heart failure (class III-IV), moderate or severe valvular disease, left branch complete blockage, moderate or severe left ventricle hypertrophy or absence of the sinus rhythm were considered. No patient was excluded due to suboptimal ultrasonic window for the evaluation of myocardial contractility by stress echo.

The indications to perform the study are summarised in Table 1.

Dipyridamole stress echo

The patients were fasted for more than 4 hours with no ingestion and xanthine medication 12 hours before the study. About 60.5% of the patients who were taking beta-blockers interrupted the medication.

Basal two-dimensional echocardiogram

The echocardiographic examinations were performed with Vivid 7 (GE Health Care, Milwaukee) equipment; an array transducer M4S 1.7–3.4 MHz was used. Images in 5 views, long apical axis, 4 and 2 chambers, and short parasternal were obtained; the fifth view corresponded to the left ventricular outflow tract pulsed Doppler as reference of the opening and closing aortic moment. The screenshots were of a complete cardiac cycle with a frame rate of 50 and 90 frames per second.

2D echo during the procedure with dipyridamole and post-procedure

After the screenshot and the digitization of the views at rest, 0.21 mg/kg of dipyridamole were intravenously injected continuously for 4 minutes. Eight minutes after the infusion of dipyridamole the early images of the same 5 views were obtained and 12 minutes later the late ones. In absence of contraindications and with negative results, 1 mg of atropine and/or handgrip was added before obtaining these last images. When the heart rate was higher than 20 bpm in regard to basal, the frames per second were increased in order to optimize the obtaining of 2D-strain. A total of 240 mg of aminophylline were used to conclude the test. When persistence of heart rate higher than the basal or ischemic response was observed, 1 mg of atenolol IV was administered. In the recovery stage the same views were obtained. The 12-channel ECG records', the taking of blood

Table 1. Population characteristics

	Total
Patients (n)	38
Age (years)	68.6 ± 10.4
Sex (men/women)	13/25
Cause of the study	
Previous revascularization, n (%)	6 (15.7)
Previous myocardial infarct (> 5 days), n (%)	9 (23.6)
Unstable angina (> 5 days), n (%)	4 (10.5)
Chronic stable angor, n (%)	3 (7.8)
Atypical chest pain, n (%)	6 (15.7)
Preoperative risk, n (%)	3 (7.8)
Dyspnoea, n (%)	4 (10.5)
Other, n (%)	3 (7.8)

pressure and heart rate were made every 4 minutes during the whole study.

Coronary flow reserve

The ADA was explored, in its mid-distal region, from a long "low parasternal" axis, with a depth of 10 cm. The long axis was modified with an inferior displacement of an intercostal space and rotation time until the right ventricle had disappeared and the anterior interventricular sulcus had localized. To confirm ADA's position, colour Doppler with a limit of Nyquist of 19.2 cm/sec was used. The ADA was seen as a tubular red structure of about 0.3 cm of diameter with a variable length and while going around the interventricular sulcus with a flow in direction to the apex (and to the transducer) shows positive spectral deflections in the Doppler with a two-phase image with greater diastolic velocity. The measures of the velocity of ADA's diastolic coronary flow were obtained at rest and without changing the transducer position the same evaluation after administering 0.21 mg/kg/min of dipyridamole during 4 minutes was made, obtaining the CFR (12-13) indexes as the relation between maximum and basal velocity.

2D-strain

Once finished the study from the apical views taken for the contractility analysis, 2D-strain was analyzed. The first thing to analyze was the apical long axis pointing three points (two basal and one apical), so the system defined in a semi-automatic way the displacement of the internal lines which follow the subendocardium and the external ones the epicardium. The tracking process was accepted or rejected and sometimes corrected manually. (9) The closure of the aortic valve, as a parameter of systolic excursion completion, was confirmed or modified; the same procedure was followed with the views of 4 and 2 chambers (always in the same sequence).

MIBI-SPECT

After the infusion of dipyridamole, 15 mCi of Tc-sestamibi were administered by IV; the post-procedure images were obtained at 40 minutes. The resting stage was made between 24 and 48 hours later with a dose of 30 mCi of Tc-sestamibi, after a fatty food. The gated thorax tomographic images were obtained in 180º with elliptical optic, in 32 frames with a high-resolution collimator and matrix of 64 x 64. The iterative method with Butterworth filters producing cuts in the long-horizontal, vertical and short axis and a file of gated SPECT for the contractile functional evaluation, was used for its processing.

Reading of the results

The analysis of the regional contractility was performed in a semiquantitative way; each segment had a score from 1 (normal) to 4 (dyskinetic). The left ventricle was divided into 16 segments according to the recommendations of the American Society of Echocardiography (4 apical, 6 medial and 6 basal). The 4 apical segments, medial septal, 2 anterior septal (medial and basal) and 2 anterior (basal and medial), a total of 9, were considered as part of ADA's area. All the studies were obtained and stored in digital format. Any new motility disorder as well as the deterioration of a previous dyssynergia during DSE was considered abnormal. (13) The CFR was obtained dividing the maximum diastolic velocity by the diastolic velocity at rest. A CFR ≥ 2 was considered normal. (14) The report of the 2D-strain consisted of the representation of the deformation curves of each segment and a summary with the value of the percentage of longitudinal regional deformation and a global value of the systolic peak of ADA's area, which was obtained averaging out the percentages of the 9 segments mentioned as representatives of the artery under study. The normal longitudinal strain for our laboratory was calculated in values of -18.5% ± 5.8% in basal segments, -19.5% for medial and -19.9 ± 6% for apical segments. The decrease of 2D-strain or an average increase < 5% in ADA's area was considered an abnormal deformation or ischemic response. (15) Myocardial perfusion, wall motion, and the enlargement with SPECT were analyzed in a semiquantitative way according to the habitual scale. The analysis of the results in the echocardiography laboratory was made by three experts (JL, VD, MA). The nuclear medicine examination was reported blindly. Interobserver variability was also evaluated. The protocol used is schematized in Figure 1.

Statistical analysis

Categorical variables are expressed as percentages and continuous as median (25/75 percentiles).

Fisher's exact test was used for the comparison of categorical variables, Mann-Whitney's test for the comparison of quantitative data of independent samples and Wilcoxon's test for the comparison of paired data.

A value of $p < 0.05$ was considered significant from the statistical point of view. Percentage error for the interobserver variability and kappa coefficient were used for the comparison of methods. Programmes as EPI info and MedCalc were used.

RESULTS

Of 568 catheterizations evaluated, 404 (71.2%) showed at least one lesion ≥ 70% of stenosis; 32.2% of the p295; 5%). Ond refused surgical alternative.

All the patients medically treated (n=28) did not show appropriate criteria for coronary revascularization, due to absence of significant ischemia or presence of small lesions.

Demographic and angiographic characteristics

A total of three patients were excluded, one due to weak signal in the ADA's pulsed Doppler which limited the CFR analysis and two due to suboptimal window for 2D-strain. The final feasibility of the study resulted in 93% (HF 95% 81-98.1).

The following results were obtained for each of the methods of ischemia analysis, considering only the response in the ADA area: 12 patients (31.5%) showed reversible perfusion defects with SPECT, 8 (21%) had an abnormal CFR response, 10 (26.3%) showed abnormalities in the 2D-strain and 6 (15.7%) developed new regional dyssynergias.

The clinical characteristics of the patients according to the presence or absence of ischemia in perfusion with SPECT are detailed in Table 2.

The deformation with 2D-strain at rest in normal and ischemic patients was of -19.9 (118, -22) vs. -19.35 (-17, -22), respectively (p= ns), while during the procedure with dipyridamole, 2D-strain was of -22.5 (-21, -26) in normal vs. 20.25 (-13, -21) in ischemic patients (p= 0.004) (Table 3). 2D-strain in normal patients was increased in an average of 13% during

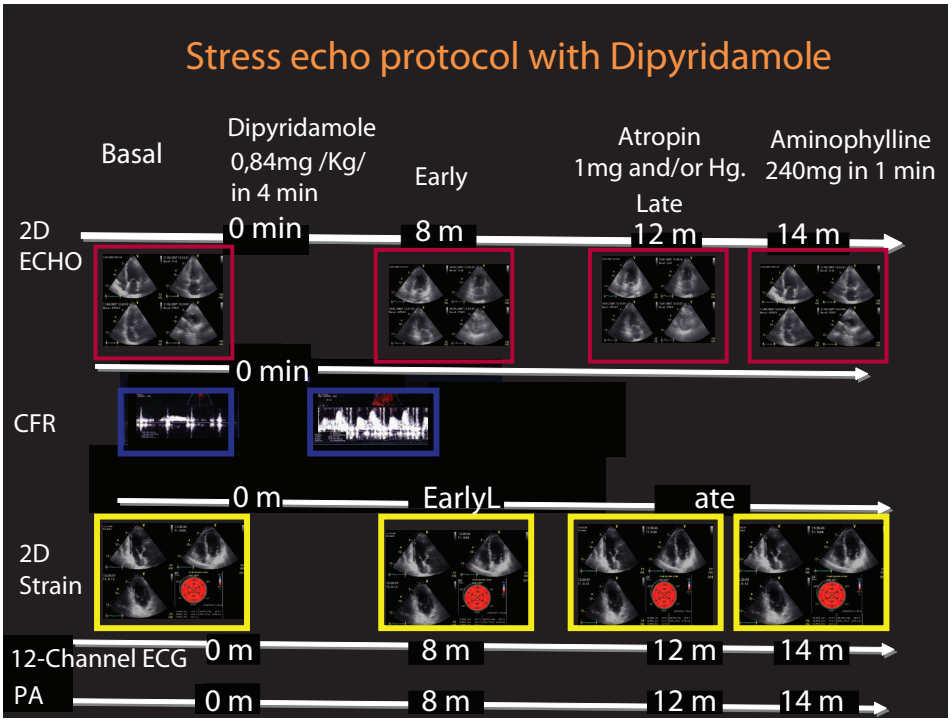

Fig. 1. Stress echo protocol with dipyridamole with simultaneous measurement of wall motion, coronary flow reserve and 2D-strain.

hyperaemia with dipyridamole, while those patients with transient perfusion defects in the average had no significant alterations (Table 3). Considering CFR values, 2D-strain increased 13% in patients with CFR normal, -19.9 (-18, -23) to -22.5 (-21, 24), p= 0.0002, and no alteration in the deformation under dipyridamole in patients with abnormal CFR was observed, -18.7 (-13, -21) vs. -19.35 (-13, -21), p= ns. (Table 3).

With respect to regional motility, those patients with no new regional dyssynerigias increased 2D-strain 15%, -19.65 (-17, -22) to -22.5 (-21, -24), p=0.0005, while those with new asynergias did not present alterations in the deformation with the pharmacological procedure, -19.35 (-17, -21) vs. -19.35 (-13, -21), p= ns (Table 3)

The behaviour of 2D-strain curves and its correlation with CFR in a patient with post-dipyridamole ischemia is exemplified in Figure 2 A. In Figure 2 B, in a normal response.

Considering the result of the perfusion with MIBI-SPECT as a pattern of ischemia, wall motion had a sensitivity of 50% (HF 95% 22.3-77.7), a specificity of 100%, a positive predictive value (PPV) of 100% (HF 95% 51.7-100) and a negative predictive value (NPV) of 81.3% (HF 95% 63.8-92.1); CFR showed a sensitivity of 66.7% (HF 95% 35.4-88.7), a specificity of 100% with a PPV of 100% (HF 95% 59.8-100) and a NPV of 86.7 (HF 95% 68.4-95.6); while 2D-strain showed a sensitivity of 83.3% (HF 95% 50.9-97), a specificity of 88.5% (HF 95% 68.7-97.1), a PPV of 76.9% (HF 95% 46-93.8) and a NPV of 92% (HF 95% 72.5-98.6). Kappa index was used in order to compare the different methods, noting that both 2D-strain and CFR showed a good concordance with myocardial perfusion (0.70 and 0.73, respectively), while motion shows a Kappa index of 0.54. Interobserver variability calculated by percentual error was of 6.9% ± 3.2%.

DISCUSION

Myocardial function has been traditionally determined by echocardiography through the visual estimation of the myocardial excursion and the parietal thickening. The regional analysis is not easy; contractility is estimated visually by the three 2D images. However this qualitative approximation has limitations, as the required experience, intraobserver and interobserver variability, and the difficulties in identifying subtle anomalies. (16-18)

It is important to remember that visual evaluation of wall motion appreciates radial myocardial deformation, while contractility consists of the deformation of longitudinal fibers with helical arrangement. (19, 20)

The deformation (strain) is the change of the length corrected to the original length or the percentage of change from the initial dimension. (21, 22)

2D-strain no Doppler is an original technique which analyzes the displacement of natural acoustic markers (speckles) uniformly distributed in the myocardium which, followed frame by frame; allow evaluating the magnitude and sense of the local parietal movement. (9) This allows the calculation of tissue movement velocity, deformation (strain) and deformation velocity (strain rate) from the two-dimensional image. The best advantage attributed to 2D-strain is that is a method of simple realization and fast interpretation that uses those images obtained in

Variable	Ischemic (n = 12)	Non- ischemic (n = 26)	p (HF 95%) Fisher's exact test
Hypertension, n (%)	9 (75)	18 (69.8)	ns
Diabetes Mellitus, n (%)	3 (25)	1 (3.8)	ns
Dyslipidemia, n (%)	9 (75)	15 (57.6)	ns
Nicotinism (smoking), n (%)	3 (25)	11 (42.3)	ns
Previous infarct, n (%)	4 (33)	5 (19.2)	ns
Stable angina, n (%)	7 (58)	6 (23)	0,033 RR 2,5 (1,08-5,9)
Angioplasty antecedent, n (%)	2 (20)	6 (23)	ns
MRS antecedent, n (%)	2 (20)	4 (15.3)	ns

MRS: Myocardial revascularization surgery; ns: non significant

Table 2. Clinical variables of the patients analyzed according to the presence of ischemia in the anterior descending artery area in the MIBI-SPECT.

Criterion	Basal 2D-strain	2D-strain dipyridamole	p (HF 95%)
Normal SPECT	–19.4 ± 5.2%	–23.3 ± 6.1%	< 0.01 (2.79-1.18)
Ischemic SPECT	–19 ± 5.3%	–18.5 ± 6.2%	ns
Reserve of ADA > 2	–18.5 ± 1.5%	–22 ± 4.4%	< 0.0002 (1.895.1)
Reserve of ADA < 2	–19.4 ± 3.6 %	–18.5 ± 4%	ns
Without asynergy	–19 ± 3.6 %	–22 ± 4.4%	< 0.002 (1.35-4.62)
New asynergy	–18.6 ± 3.5 %	–18.8 ± 4%	ns

Table 3. 2D-strain determination in view of different ways of detecting ischemia

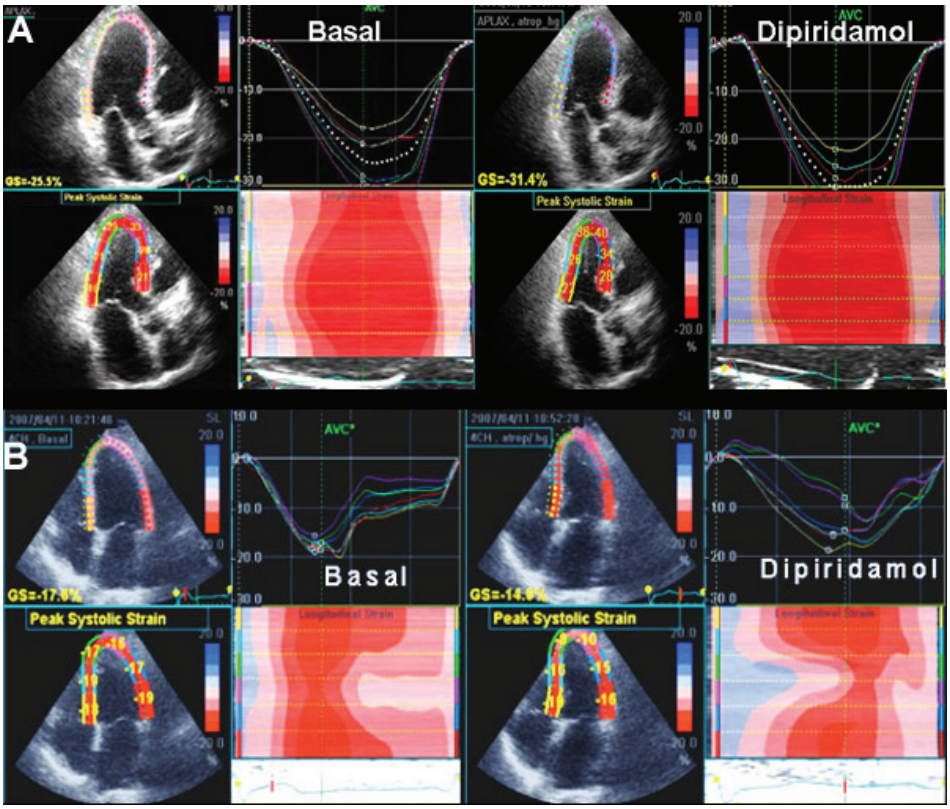

Fig. 2. A. Example of basal 2D-strain and post-dipyridamole with normal response, with no changes in contractility with CFR of 3 and normal gated SPECT. **B.** Example of Basal 2D-strain and post-dipyridamole with evident impairment of the percentages of deformation in the segments of the ADA area. With no changes in contractility with a CFR of 1.6 with SPECT compatible with apical and anterior ischemia.

a cardiac cycle of 3 views and as it is not based on Doppler effect is independent of the exploration angle; it can be applied to all myocardial segments and its results are validated by sonomicrometry and magnetic resonance tagging. (9, 23, 24)

The evaluation of the CFR is useful in order to know the functional repercussion of a coronary stenosis. (4, 25-28) The results of the simultaneous evaluation of contractility and CFR during stress echo were communicated by our group of work, who used it with all the pharmacological procedures. (7, 8) A meta-analysis has proved that DSE diagnostic sensitivity and effectiveness increase if the information of CFR is added. (29) However, this modality of simultaneous study is not systemized as a routine method and most of the laboratories focus on the contractility analysis results'.

The main reason of our study was to make a

comparison between the transient dyssynergias, CFR values, and the behaviour of 2D-strain during DSE using in a simultaneous way the MIBI-SPECT as ischemia gold standard.

The results confirmed the high feasibility both of CFR (97.5%) and 2D-strain (95.1%), limited only by a suboptimal ultrasonic window. Total feasibility of the study was of 92.7%.

A total of twelve patients were considered ischemic in the ADA area by SPECT, 6 were positive by the three methods. Of the 26 negative patients for myocardial perfusion, 23 were negative by the three methods coming from echocardiographies.

DSE's specificity was excellent (100%) both in contractility analysis and CFR; however sensitivity was not ideal. With 2D-strain a significant increase of the sensitivity of the test with regard to contractility analysis (83.3% vs. 50%; p= 0.001) could be obtained, with a non significant loss in specificity.

The differences in sensitivity and specificity between CFR and 2D-strain were not statistically significant, although CFR had better specificity and 2D-strain showed better sensitivity. Concordance between 2D-strain and CFR was good, with a kappa index of 0.70.

It was important to prove that the increase of flow produced by the vasodilator procedure is expressed as an increase of systolic deformation by 2D-strain, possibly in order to improve the conditions of microcirculation in myocardial fibers (Gregg effect).

In contrast, flow theft as an ischemic response was expressed in 2D-strain deterioration. (Figure 2). Gregg's effect states that the increase of perfusion pressure increases the microvascular volume and in this way the opening of ionic channels, with the result of an increase in transient intracellular Ca ++, which is followed by an increase of sensitivity to calcium and greater muscular contractility. (30)

In this study, patients with perfusion or abnormal CFR did not increase deformation during the hyperaemia induced by dipyridamole.

Those results saying that CFR is superior to the visual analysis of motility in the detection of myocardial ischemia during stress echo with vasodilators are confirmed. (7, 8, 28, 29) The quantitive regional analysis with 2D-strain showed results comparable to CFR in the detection of ischemia.

Limitations

This study was limited to the ADA area, due to its high feasibility of measuring its CFR, so to demonstrate that 2D-strain has the same correlation in other areas new studies should be done.

We have only evaluated longitudinal 2D-strain; probably some important information about radial, circumferential, and of torsion movements strain has been lost.

The number of patients was not very high, but representative of those who are treated in our laboratory.

The chosen gold standard, MIBI-SPECT, is not perfect and some studies listed by the CFR, parietal analysis or 2D-strain as false positives or false negatives may have been classified in a wrong way; however, as a functional study, SPECT is the most recognized due to its effectiveness and the only one accessible in our environment for simultaneous evaluations.

CONCLUSIONS

2D-strain based on the speckle tracking technique to determine ischemia during stress echo with dipyridamole proved to be a quantitative, feasible and simple method, with effectiveness similar to the one of the CFR.

DSE is the ideal study to analyze 2D-strain, due to the absences of high heart rate produced by exercise or dobutamine. An average increase > 5% of 2D-strain values during DSE helps excluding ischemia, due to its high negative predictive value (92%).

The use of this study does not want to replace the visual analysis of regional parietal contractility, but it adds important information equivalent to the CFR.

The three parameters, contractility, 2D-strain, and CFR, should not be seen as alternative techniques, but as complementary and additive during stress echocardiography; however, those laboratories that do not make the determination of CFR have the option to use 2D-strain, which may be an excellent alternative.

Is important to emphasise that in the laboratory of stress echo, where time is limited, is useful to have a simple, objective and fast method as 2D-strain.

RESUMEN

Análisis simultáneo del strain 2D, de la reserva coronaria y de la contractilidad parietal durante el eco estrés con dipiridamol. Resultados comparativos

Introducción

El eco estrés con dipiridamol (ECODIP) es una prueba farmacológica aceptada para la eva¬luación de pacientes con cardiopatía isquémica; está demostrado que es una técnica ideal para combinar la información visual de la contractilidad con la reserva coronaria (RC), pero no se tiene información respecto del uso del strain 2D (deformación bidimensional) para el diagnóstico de isquemia miocárdica, por lo que su evaluación y la comparación de los resul¬tados con otros métodos actuales para la determinación de isquemia regional puede ser de singular interés práctico.

Objetivo

Comparar, durante el ECODIP, los resultados del análisis visual de la motilidad parietal con el valor de la RC de la arteria descendente anterior (ADA) y con el comportamiento del strain 2D longitudinal en el mismo territorio, utilizando la perfusión miocárdica con ^{99}Tc sestamibi con SPECT simultáneo como patrón oro para el diagnóstico de isquemia.

Material y métodos

Se evaluaron 41 pacientes (16 hombres; edad promedio 68,5 años) derivados para ECODIP. Se promedió el strain 2D longitudinal obtenido en los 9 segmentos correspondientes a la ADA desde las tres vistas apicales tanto en reposo como en estrés, considerando como isquemia a la reducción en la deformación o un incremento menor del 5%. En el pico de efecto de 0,84 mg/kg de dipiridamol se evaluó también la motilidad parietal, la RC de la ADA (normal: > 2) y se inyectó ^{99}Tc sestamibi para SPECT en estrés, completando su vista en reposo a las 24-48 horas.

Resultados

Se excluyeron 3 pacientes, uno por señal deficiente en la ADA y dos por ventana subópti¬ma para el strain 2D. Doce pacientes con defectos reversibles con SPECT se consideraron isquémicos. Se observó concordancia de los cuatro parámetros evaluados en 6 pacientes con todos los estudios anormales y en 23 con todos los estudios normales. La deformación longitudinal en el territorio de la ADA en pacientes con SPECT normal fue de –19,9% (–18, –22) en reposo y de –22,5% (–21, –26) en el pico del ECODIP (p = 0,0003). En pacientes con SPECT isquémico, el strain 2D fue –19,35% (–17, –22) en reposo y –20,25% (–13, –21) en el pico del ECODIP (p = ns). La RC mostró una sensibilidad del 66,7% (IC 95% 35,4-88,7) y una especificidad del 100%; la contractilidad, una sensibilidad del 50% (IC 95% 22,3-77,7) y una especificidad del 100% y el strain 2D, una sensibilidad del 83,3% (IC 95% 50,9-97) y una especificidad del 88,5% (IC 95% 68,7-97).

Conclusiones

El strain 2D durante el eco estrés con dipiridamol resultó un método cuantitativo factible con una efectividad similar a la RC y superior al análisis visual de la contractilidad para detectar isquemia en el territorio de la ADA.

Palabras clave > Ecografía - Estrés fisiológico - Dipiridamol Contractilidad cardíaca

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Conflict of interest statement

All the authors listed in the work have made possible with their contribution the production of this study and accept the terms of the Editorial Committee assuring that none of them has direct or indirectly any conflict of interest.