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Original Research

Correlation of contrast echocardiography with location of coronary stenosis in myocardial infarction with right ventricle extension

Correlación de ecocardiografía de contraste con la localización de la estenosis coronaria en infarto de miocardio con extensión al ventrículo derecho

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ABSTRACT. Introduction: Contrast echocardiography (CE) is an important diagnostic tool for routine clinical use in the assessment of the patient with acute coronary syndrome (ACS). Its utility in elucidating the functional status of the right ventricle (RV), is hypothesized to be of use when evaluating the prognosis and hence the need for a prompt intervention. Used in the setting of an ACS, CE can predict which patients are likely to have proximal obstruction of right coronary artery (RCA). Based on that premise, when the clinical suspicion of proximal RCA obstruction is suspected, we can confidently proceed to an earlier intervention. The aim of the study was to determine if the magnitude of the RV perfusion defects correlates with the stenosis site of RCA. **Methods and results:** We studied 24 patients with ACS, in which a CE was performed previous to a coronary angiography. A statistical correlation was made to demonstrate the severity of the obstruction in terms of location; with the walls affected, seen with CE. A direct correlation was found when more than two walls were involved. Those patients had proximal RCA obstructions, and therefore a worse prognosis. **Conclusion:** There is a good correlation between the magnitude of the perfusion defect observed by CE and the stenosis site of the responsible coronary artery.

Keywords: Contrast echocardiography, perfusion defect, right ventricle myocardial infarction, coronary stenosis.

RESUMEN. Introducción: La ecocardiografía de contraste (EC) es una importante herramienta de diagnóstico para el uso clínico de rutina en la evaluación del paciente con síndrome coronario agudo (SCA). Su utilidad para dilucidar el estado funcional del ventrículo derecho (VD) podría usarse para evaluar el pronóstico y, por lo tanto, la necesidad de una intervención rápida. Utilizado en el contexto de un SCA, la EC puede predecir qué pacientes tienen probabilidad de tener una obstrucción proximal de la arteria coronaria derecha (CD). Sobre la base de esa premisa, cuando existe sospecha clínica de obstrucción de la CD proximal, podemos proceder con confianza a una intervención más temprana. El objetivo del estudio fue determinar si la magnitud de los defectos de perfusión del VD se correlaciona con el sitio de estenosis de CD. **Métodos y resultados:** Se estudiaron 24 pacientes con SCA, en los que se realizó un EC previo a una angiografía coronaria. Luego se realizó correlación estadística para demostrar la gravedad de la obstrucción en términos de ubicación con las paredes afectadas. Se encontró una correlación directa cuando se involucraron más de dos paredes. Esos pacientes tenían obstrucciones de la CD proximal y, por lo tanto un peor pronóstico. **Conclusión:** Existe una buena correlación entre la magnitud del defecto de perfusión observado por la EC y el sitio de la estenosis de la arteria responsable.

Palabras clave: Ecocardiografía con contraste, defecto de perfusión, infarto de miocardio de ventrículo derecho, estenosis coronaria.

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INTRODUCTION

The assessment of ventricular function is very important in the clinical course of some cardiovascular diseases such as acute myocardial infarction with extension to the right ventricle (RV). In these cases, functional assessment at different times is crucial, due to its prognostic and therapeutic implications.¹⁻³ The proximal occlusion of the right coronary artery (RCA) compromises the perfusion of the ventricular branches, which leads to RV dysfunction, whereas distal occlusion rarely produces such an effect.

The intravenous administration of contrast substances that cross the pulmonary barrier allows the obtention of an adequate visualization of the endocardium and therefore an excellent delimitation of the three portions of the RV, such as the tract of entry, the trabecular portion and the outflow tract. This facilitates the measurement of RV areas in diastole and systole, even in patients with poor acoustic window and also allows an accurate assessment of the coronary microcirculation.⁴⁻⁶ There are many studies in the literature that have evaluated the coronary microcirculation in patients with left ventricular infarction,^{6,7} but there are still no studies in humans that assess the coronary microcirculation of the RV in the presence of a posteroinferior infarction with extension to the right cavities.

MATERIAL AND METHODS

Design and population: This is a prospective, double blind and observational study. Performed from October 2002 to July 2003, 24 consecutive patients of the Coronary Care Unit of *Instituto Nacional de Cardiología «Ignacio Chávez»* (Mexico City) were included, with a diagnosis of myocardial infarction of the posteroinferior wall of the left ventricle with extension to the RV. We included patients with acute myocardial infarction presenting with precordial oppressive pain of more than 30 minutes duration and ST segment elevation greater than 1 mm in at least two contiguous leads of the inferior wall of the left ventricle and enzymatic elevation of creatine phosphokinase at twice higher than its normal value. To determine the extent of

the infarction to the RV, the following criteria were considered: elevation of the ST segment greater than 1 mm in the right leads V3r and/or V4r. We excluded patients with a history of: old myocardial infarction, severe chronic lung disease that would have required hospitalization or oxygen therapy, congenital heart disease, cardiomyopathies, constrictive pericarditis or pulmonary arterial hypertension. All patients underwent conventional transthoracic CE and coronary angiography. All patients received follow-up during their hospital stay. The end points during the follow-up were death, development of cardiogenic shock, low cardiac output and rhythm disorders.

Echocardiogram: The conventional transthoracic echocardiogram was performed with a Hewlett Packard Sonos 5500, equipped with an S3 transducer. In the 4-chamber apical plane, the mobility of both ventricles was assessed and it was considered normal when parietal mobility and systolic thickening were symmetric; hypokinesia when decreased parietal mobility and systolic thickening were present; akinesia when parietal mobility and systolic thickening were absent and dyskinesia when there was outward systolic bulging of a certain segment. The shortening fraction of areas of the right ventricle (SFA-RV) was determined in the apical four chamber view, delimiting the area of the RV in the end diastole and in the telesystole with the following formula: $(ADV-ASVD/ADVD) \times 100$. The SFA-RV was considered normal when the value was equal to or greater than 40%. The right ventricle ejection fraction (RVEF) was calculated with the values of the descent of the tricuspid annulus in diastole and in systole, in the apical four chamber view. The formula $DanTD-DanTS$ was used and the difference obtained was multiplied by 3.2. The RVEF was considered normal when the value was equal to or greater than 44%. For CE, a Sonos 5500 instrument with harmonic perfusion and Doppler angio software was used. For the assessment of the coronary microcirculation of the RV, the images were used in the short parasternal axis at the level of both ventricles and apical four chamber view. Optison (perfluoropropane with diameter of the microbubbles of 3.7 microns) was applied intravenously per ulnar vein, in bolus at a rate of 0.4 mL/minute, with a 3 mL

Table 1: Contrast echocardiogram BEFORE reperfusion treatment.

Number of patients	Number of walls with absence of perfusion	Site of coronary obstruction	>1 vessel affected	Collateral circulation	Clinical evolution	End point
2	3	Proximal RCA	Yes	No	Cardiogenic shock, rhythm disturbances	Dead
1	2	Proximal RCA	Yes	Yes	Cardiogenic shock, AV block	Alive
1	2	Proximal RCA	Yes	Yes	Cardiogenic shock, AV block	Alive
1	1	Proximal RCA	No	Yes	Low output, A-Fib	Alive
1	1	Distal RCA	No	No	Stable	Alive
2	Normal	Medial Cx	No	No	Low output	Alive
1	Normal	Proximal RCA	No	Yes	Low output	Alive

RCA = Right coronary artery; Cx = Circunflex artery.

saline solution bolus and subsequently at a rate of 1 mL/minute. Microvascular myocardial perfusion with harmonic and angio Doppler was evaluated, using the triggered modality in telesystole with shots of 1: 1, 1: 5. The contrast image was considered adequate when the gray scale was greater than 70 pixels. The coronary microcirculation was measured qualitatively in the walls of the RV and it was determined to be normal when the distribution of the microbubbles was homogeneous in the three walls of the RV: anterior, free and inferior wall. Hypo perfusion was determined when heterogeneous distribution of the microbubbles was observed in some of the walls and absence of perfusion; when there was absence of microbubbles in any of the walls of the right ventricle. Perfusion images with contrast, RV function and mobility were correlated with coronary angiography at the site of the lesion and coronary flow. The CE was evaluated qualitatively by two echocardiographers and the site of stenosis and flow in the coronary artery related to the infarction were assessed by an interventional cardiologist based on the TIMI classification.

Statistic analysis: The data were represented in a contingency table and the

Spearman correlation coefficient was calculated to determine the degree of correlation between the CE and coronary angiography. The intra- and inter-observer concordance was assessed with the Kappa index in the perfusion images of the walls of the RV.

RESULTS

Twenty-four patients were studied: 21 (87.5%) were males, with an average age of 58 ± 13 years (35-76). Nine patients had dyslipidemia, 9 diabetes mellitus type II, 9 arterial hypertension and 7 exogenous obesity. At admission, 18 patients (75%) had ST segment elevation in V3r and V4r. The average value of creatine phosphokinase was $2,032 \pm 1,407$ U/dL (11-4,100). The average MB fraction was 142 ± 102 U/dL (18-400). Fifteen patients (62.5%) arrived within the therapeutic window. CE was performed in 9 patients before reperfusion treatment, whether they were in a therapeutic window (TW) or outside it (OTW). Two patients (one OTW and the other TW) presented three-wall hypoperfusion or absence of perfusion of the RV; coronary angiography showed affection of the proximal segment of the right coronary artery (RCA); angioplasty

failed in both patients and they died. In one TW patient, there was hypoperfusion of the three walls and perforation of RV. He presented atrioventricular (AV) block and cardiogenic shock; coronary angiography revealed involvement of the proximal segment of the RCA; after revascularization, hemodynamic state improved. In other OTW patient, hypoperfusion was detected in two walls of the RV and presented AV block and cardiogenic shock, after revascularization the patient remained stable; coronary angiography showed obstruction of the proximal segment of the RCA. In 1 OTW patient, hypoperfusion was found in one RV wall, presented with atrial fibrillation and low cardiac output; its coronary angiography showed proximal RCA lesion with improvement after revascularization. All these patients mentioned above have decreased RVEF and SFA-RV. One TW patient presented with hypoperfusion of RV wall and normal RVEF and SFA-RV, with a good evolution. Coronary

angiography showed slow flow and thrombus in the distal segment of the RCA. In 2 patients the RV perfusion was normal (one TW and another OTW) and mid dominant circumflex segment lesion was observed. The EC showed normal perfusion in one patient with proximal RCA lesion (Table 1).

The EC performed in 9 patients after reperfusion treatment OTW or TW demonstrated: 3 patients presented perfusion disorders; (1) TW patient with hypoperfusion of free and posterior wall with decreased RVEF and SFA-RV, and ostial RCA lesion with a failed reperfusion therapy, the patient died. (2) OTW patient with posterior wall hypoperfusion, normal RVEF and SFA-RV, and proximal RCA lesion with a failed reperfusion therapy, showed hemodynamic stability. (3) One patient after failed thrombolysis, anterior hypoperfusion was found in the EC and lesion in the middle RCA. In 6 patients, the EC of the RV was normal, one with proximal RCA, five with mid RCA (Table 2).

Table 2: Contrast echocardiogram AFTER reperfusion treatment.

Number of patients	Number of walls with absence of perfusion	PTCA and Site of coronary obstruction	> 1 vessel affected	Collateral Circulation	Clinical evolution	Endpoint
1	3	Proximal RCA, PTCA failed	Yes	No	Cardiogenic shock	Death
1	1	Proximal RCA, PTCA failed	No	Yes	Stable	Alive
1	1	Medial segment Trombolysis failed	No	Yes	Stable	Alive
1	Normal	Proximal RCA, PTCA success	No	No	Stable	Alive
2	Normal	Medial RCA, PTCA success	No	No	Stable	Alive
3	Normal	Medial RCA, PTCA success	No	No	Stable	Alive

RCA = Right coronary artery; PTCA = Percutaneous transluminal coronary angioplasty.

The correlation between CE and coronary angiography was 0.77. The intra- and inter-observer concordance in the perfusion images of the walls of the right ventricle was 0.84 and 0.83, respectively.

DISCUSSION

Patients who present with a diagnosis of infarction of the posteroinferior myocardium with extension to RV, outside of a therapeutic window for thrombolysis or primary angioplasty, the EC will provide information on how severe the ischemia is, determining the site of obstruction of the lesion and therefore leading us to take the decision of urgent or elective revascularization in these patients.⁷⁻⁹ The EC can help during the first week of the infarction, since it allows assessing the right ventricular function without the need to transfer the patient to the nuclear cardiology study.¹⁰ Alterations in RV perfusion are related to RV dysfunction and unfavorable clinical evolution. When two or more walls of the right ventricle are affected, obstruction is found in the proximal segment of the RCA, there are important obstructive lesions in more than two vessels and there is no collateral circulation. When the RV perfusion remained normal due to probable spontaneous thrombolysis or presence of collaterals before reperfusion, the clinical evolution was favorable.

Now if we relate the clinical state and RV perfusion, we observed that there were conduction disorders and cardiogenic shock in absence of perfusion or hypoperfusion of two or more RV walls. The EC shows that when the perfusion is normal or there is hypoperfusion of a single wall, it must be related to involvement of either the middle segment of the RCA or the circumflex and/or the presence of collateral circulation. When the reperfusion treatment fails and there is hypoperfusion in more than one RV walls, it is related to a lesion in the proximal segment and involvement in more than two vessels, with absence of collateral circulation. In presence of collateral circulation prognosis is better.

CONCLUSIONS

The clinical evolution is not favorable when there are defects of myocardial perfusion in two or more walls of the RV and lesions in other vessels without collateral circulation. The absence of perfusion of the RV and its dysfunction is mainly due to involvement of the proximal segment and is related to higher mortality. The proximal occlusion of the RCA causes RV dysfunction. There is a good correlation between the magnitude of the perfusion defect observed by CE and the stenosis site of the responsible coronary artery.

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