

Value of NT-ProBNP Level and Echocardiographic Parameters in ST-Segment Elevation Myocardial Infarction Treated by Primary Angioplasty: Relationships Between These Variables and Their Usefulness as Predictors of Ventricular Remodeling

José López Haldón,^a Mónica Fernández Quero,^a Fernando Mancha,^b José A. Urbano^a, Agustín Guisado,^a Manuel Villa,^a Juan I. Valle,^a María J. Rodríguez Puras,^a Sara Ballesteros,^a Francisco López Pardo,^a Luis Díaz de la Llera,^a Ángel Sánchez González,^a and Ángel Martínez Martínez^a

^aÁrea del Corazón, Hospitales Universitarios Virgen del Rocío, Sevilla, Spain

^bServicio de Bioquímica, Hospitales Universitarios Virgen del Rocío, Sevilla, Spain

Introduction and objectives. To assess the value of N-terminal fragment of brain natriuretic peptide (NT-proBNP) measurement and echocardiography for predicting ventricular remodeling after myocardial infarction and to investigate relationships between the NT-proBNP level and echocardiographic parameters at discharge and in the medium term.

Methods. The study involved 159 patients with myocardial infarction treated by primary coronary angioplasty. The NT-proBNP level was measured on admission, at discharge and after 6 months. Echocardiography was performed at discharge and after 6 months.

Results. Overall, 31 patients (19.5%) demonstrated remodeling. At discharge, the variables associated with remodeling were: mitral inflow E-wave-to-A-wave velocity ratio (E/A), systolic mitral annulus velocity (Sm), early diastolic mitral annulus velocity (Em), the mitral inflow E wave to early diastolic mitral annulus velocity ratio (E/Em), left atrial volume (LAV), left ventricular end-systolic volume (LVESV), left ventricular end-diastolic volume (LVEDV), and discharge NT-proBNP level. Only E/Em was an independent predictor of ventricular remodeling (odds ratio [OR]=1.143; 95% confidence interval [CI], 1.039-1.258; $P=.006$). At discharge, correlations were observed between the NT-proBNP level and LVEDV, LVESV, ejection fraction (EF) and E/Em. At 6 months, correlations with ventricular volumes and EF were unchanged, the correlation with E/Em was better ($r=0.47$ vs. $r=0.69$), and a modest correlation with LAV developed ($r=0.43$; $P=.001$).

Conclusions. The E/Em ratio was the best echocardiographic predictor of left ventricular remodeling after myocardial infarction. The NT-proBNP level had no additional predictive value over echocardiography.

Correlations between the NT-proBNP level and ventricular volumes and EF at discharge and 6 months were similar, while correlations with E/Em and LAV were better at 6 months.

Key words: Myocardial infarction. Natriuretic peptides. Echocardiography.

NT-proBNP y variables ecocardiográficas en el infarto con elevación del ST tratado con angioplastia primaria: relación entre ambos y utilidad como predictores de remodelado ventricular

Introducción y objetivos. Estudiar el valor del fragmento aminoterminal del péptido natriurético cerebral (NT-proBNP) y del ecocardiograma para predecir remodelado tras infarto y relacionar el NT-proBNP con el ecocardiograma al alta y en fase crónica.

Métodos. Estudiamos a 159 pacientes con infarto tratados con angioplastia primaria. Se determinó el NT-proBNP al ingreso, al alta y al sexto mes. Se hizo ecocardiograma al alta y al sexto mes.

Resultados. Treinta y un pacientes (19,5%) sufrieron remodelado. Al alta se asociaron con remodelado: el cociente entre velocidades E y A del llenado mitral (E/A), la velocidad sistólica del anillo mitral (Sm), la velocidad diastólica precoz del anillo mitral (Em), el cociente entre onda E del llenado mitral y velocidad diastólica precoz del anillo mitral (E/Em), el volumen auricular izquierdo (VAI), los volúmenes telediastólico (VTD) y telesistólico (VTS) ventriculares izquierdos y el NT-proBNP al alta. De ellas, sólo el E/Em fue predictor independiente de remodelado (odds ratio [OR] = 1,143; intervalo de confianza [IC] del 95%, 1,039-1,258; $p = 0,006$). Al alta, el NT-proBNP se correlacionó con el VTD, el VTS, la fracción de eyección (FE) y el E/Em. Al sexto mes, había similar correlación con volúmenes ventriculares y FE, mejoró la correlación con el E/Em ($r = 0,47$ frente a $r = 0,69$) y apareció correlación modesta con el VAI ($r = 0,43$; $p = 0,001$).

Conclusiones. El cociente E/Em es el mejor predictor ecocardiográfico de remodelado tras infarto. El NT-proBNP pierde valor predictor al considerarlo junto con el ecocardiograma. El NT-proBNP se correlaciona igual-

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Correspondence: Dr. J. López-Haldón.
Área del Corazón, Hospitales Universitarios Virgen del Rocío.
Avda. Manuel Siurot, s/n. 41013. Sevilla. Spain
E-mail: josee.lopez.sspa@juntadeandalucia.es

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ABBREVIATIONS

EDV: end-diastolic volume
 ESV: end-systolic volume
 LVR: left ventricular remodeling
 NT-proBNP: N-terminal fragment of brain natriuretic peptide
 PCI: percutaneous coronary intervention
 STEMI: ST segment elevation myocardial infarction

mente con volúmenes ventriculares y FE al alta y al sexto mes, mientras que la correlación con el cociente E/Em y el VAI es más relevante al sexto mes.

Palabras clave: Infarto de miocardio. Péptidos natriuréticos. Ecocardiografía.

INTRODUCTION

Left ventricular remodeling (LVR) after myocardial infarction with ST elevation (STEMI) is a predictor of heart failure and death.¹ Traditionally ejection fraction (EF) has been the most frequently used ultrasound parameter to predict the evolution of patients who have suffered a STEMI.² The quantification of left filling pressure using the rate E/Em (E: early diastolic mitral filling flow velocity; Em: early diastolic mitral annular velocity) can be a better predictor of LVR than EF.³ Few studies with very few patients, have studied the prognostic value of ultrasound in patients with STEMI.

The brain natriuretic peptide (BNP) and its N-terminal fragment (NT-proBNP) are secreted by cardiomyocytes as a response to stretch, and are elevated when there is ventricular dysfunction⁴; but the plasma levels of these substances can also be affected by age, sex, obesity, or renal failure. The correlation with ventricular function parameters is not very pronounced, and there is a "grey area" in which BNP values do not make it possible to either confirm or rule out ventricular dysfunction.⁵ These peptides are of prognostic value in patients with STEMI.⁶ There are few studies that compare the predictive value of these peptides with ventricular function variables obtained by ultrasound after STEMI.⁷ The correlation of these peptides and ventricular function at different moments in time after STEMI has not been studied.

The objectives of this study are: *a*) to determine if NT-proBNP is useful to predict LVR when it is

added to ultrasound measurements of ventricular function; *b*) to study the correlation between levels of NT-proBNP and ventricular function at 2 moments in time after STEMI: on discharge and during the subsequent chronic phase.

METHODS

Patients

Hospital Universitario Virgen del Rocío has a primary percutaneous coronary intervention (PCI) program that operates 24×7, 365 days a year. We included in the study, prospectively and consecutively, 222 patients with STEMI who underwent primary PCI between January 2007 and April 2008. A patient was considered to be suffering from STEMI when the following were present: ischaemic chest pain ≥30 minutes, ST elevation >1mm in ≥2 contiguous leads on the limbs or >2mm in ≥2 precordial contiguous leads, not normalized by nitroglycerine. Exclusion criteria were: refusal to sign consent, impossibility of determining the culprit artery that caused the infarction, non-successful PCI, presence of other significant heart disease (valve condition, cardiomyopathy, or pericardial disease) or non-cardiac disease that limits life expectancy. Of the 222 primary PCIs, 213 (96%) were successful. A PCI was considered successful if the residual stenosis of the responsible artery was <30%, with a TIMI-3 flow. Of the 213 successful primary PCIs, 8 patients (3.7%) died during hospitalization and 11 patients were not included because no blood sample was taken at the time of the PCI. The remaining 194 patients were discharged and followed-up for this study. In the course of the 6 months between discharge and the 2nd ultrasound control, 16 patients were excluded due to: sudden death (1), reinfarction (5), restenosis with clinical symptoms (7), and disease progression with clinical symptoms (3). Of the remaining 178 patients, the second ultrasound study was not available for 14 patients because they came from another hospital area and for 5 patients because they refused to participate in the follow-up study. The final population of the study was 159 patients. The Hospital Ethics Committee approved the study design.

Blood Sampling and Measurement of NT-proBNP

Blood for NT-proBNP determination was sampled at 3 points in time: before the intervention, at hospital discharge, and 6 months after the event. An enzyme immunoassay technique was used (Elecys 2100, Roche Diagnostics).

Ultrasound Study

All patients were submitted to a transthoracic ultrasound at discharge and at 6 months. These ultrasound studies were performed with an iE33 (Philips) ultrasound at the time of blood sampling to detect NT-proBNP levels. The images were recorded in DICOM (Digital Imaging and Communication in Medicine) format for subsequent quantification, which was carried out by a cardiologist accredited in advanced echocardiography by the Spanish Society of Cardiology. In each study the following were registered: velocities E and A of mitral filling and the ratio of these (E/A), mitral flow propagation velocity (Vp), the E/Vp ratio, systolic velocity (Sm), early diastolic (Em) and late diastolic (Am) with tissue Doppler of the septal mitral ring, and left atrial volume indexed by body surface area in m² (LAV). If mitral regurgitation was detected it was quantified according to the size of the effective regurgitant orifice using the PISA (Proximal Isovelocity Surface Area)⁸ method. After these studies 1 or 2 boluses of 0.5 mL of contrast (SonoVue®, Rovi) were injected in patients and a video clip was taken to determine end of diastole volume (EDV) and end of systole volume (ESV) using the Simpson biplane method, both indexed by body surface area in m², and left ventricle EF. Keeping in mind the methods used in previous studies that analyzed LVR after primary PCI, remodeling was considered to exist if there was an increase $\geq 20\%$ of EDV in the echocardiograms taken at 6 months in comparison with the discharge echocardiogram.^{9,10} Patients were injected with contrast in all studies with the aim of reducing variability in the measurements of ventricular volumes to a minimum, a fact demonstrated with contrast even in patients with good endocardial border definition in the baseline study.¹¹ SonoVue® contrast contains sulphur hexafluoride and is contraindicated in patients with “evolving or ongoing myocardial infarction.”¹² We performed the first echocardiogram the day the patient was discharged from hospital—median, 5 days, [interquartile range, 4-10 days]—, when the patient had overcome the acute phase and was clinically and haemodynamically stable. Other recent studies have safely used contrast on the 5th day after infarction.¹³ All patients were clinically and electrocardiographically monitored during the study. Close clinical monitoring was performed for at least 30 minutes after the end of the study.

Statistical Analysis

Continuous variables were expressed as mean (standard deviation [SD]) and the discrete variables as frequencies in percentages. To compare qualitative variables the χ^2 test was used. Quantitative

variables were compared using the Student *t* test for independent samples. For multivariate analysis of remodeling prediction, a forward stepwise binary logistic regression was applied. Correlation between NT-proBNP values and echocardiographic measurements was determined using the Pearson *r* coefficient.

RESULTS

For the 159 patients included in the study, mean age was 60 (11) years (range, 35-83 years), and there were 25 women (15.7%). Mean time of ischaemia (symptom-onset-to-balloon time) was 202 (118) minutes. Of these 159 patients, 31 (19.5%) underwent LVR. The median time from the STEAMI event to the first echocardiographic study was 5 days (interquartile range, 4-10 days) and the second study was 199 days (interquartile range, 174-218 days). In Table 1 it is possible to see baseline clinical and demographic characteristics of the patients. Patients who developed LVR had a greater frequency of culprit lesion in the left anterior descending artery (LAD) (63% vs 30%; $P=.001$) and a greater area of infarction quantified by maximum troponin T value (9.90 [7.23] ng/mL vs 4.11 [3.57] ng/mL; $P=.001$). Furthermore, patients who underwent LVR showed a non-significant tendency to suffer a longer ischemic period (186.2 [109.3] min vs 264.6 [172.2] min; $P=.079$). Surprisingly, there was a lower percentage of smokers among the patients that underwent LVR compared to those that did not (32% vs 63%; $P=.003$).

Echocardiography and NT-proBNP Levels at Discharge as LVR Predictors

The use of contrast was safe. Only 2 patients suffered reactions: one patient had hypotension that responded to saline and the other had self-limiting pruritus and erythema of the palms of the hands.

Mean EF at discharge was 58% (11%) (range, 26%-88%). Thirty-eight patients (24%) had an EF $< 50\%$ at discharge and 12 (7.5%) had an EF of $< 40\%$. Table 2 shows the differences between patients that underwent LVR and those that did not with respect to echocardiographic variables at discharge. Patients who underwent LVR had a greater E/A ratio (1.2 [0.8] vs 1.1 [0.4]; $P=.005$), a lesser Sm velocity (6.4 [1.7] cm/s vs 7.1 [1.3] cm/s; $P=.043$), and a greater E/Em ratio (17.9 [8.5] vs 13 [4.2]; $P=.001$), LAV (30.2 [10.4] mL/m² vs 27.9 [7.7] mL/m²; $P=.014$), EDV (57.1 [15.2] mL/m² vs 56.2 [11.3] mL/m²; $P=.019$) and ESV (27.6 [13.4] mL/m² vs 22.8 [9.9] mL/m²; $P=.027$). Patients with LVR also had higher levels of NT-proBNP at discharge (1957 [2000] pg/mL vs 945

TABLE 1. Baseline Characteristics of Both Groups

	No Remodeling (n=128)	Remodeling (n=31)	P
Age, mean (SD), y	58.7 (10.7)	61.9 (11.8)	.8
Women	21 (16%)	4 (13%)	.63
Hypertension	49 (39%)	16 (53%)	.14
Diabetes	31 (24%)	5 (17%)	.38
Smokers	80 (63%)	10 (32%)	.003
Prior coronary disease (prior infarction, stenosis >50%)	10 (8%)	2 (7%)	.82
Prior infarction	8 (6%)	1 (3%)	.53
Disease ≥2 vessels	53 (41%)	16 (52%)	.30
Vessel affected			
LAD	38 (30%)	19 (63%)	.001 ^a
LCX	19 (15%)	2 (6%)	
RCA	70 (55%)	11 (35%)	
Symptom-onset-to-balloon time, min	186.2 (109.3)	264.6 (172.2)	.08
Maximum TnT, ng/mL	4.11 (3.57)	9.9 (7.23)	.001
ACEI or ARB-II at discharge	117 (92%)	30 (97%)	.37
Betablocker at discharge	122 (95%)	29 (90%)	.27
Statin at discharge	125 (98%)	31 (100%)	.39

ACEI indicates angiotensin converting enzyme inhibitor; LAD, left anterior descending artery; LCX, circumflex artery; RCA, right coronary artery.

^aLAD versus other vessel.

Qualitative variables are in percentages and quantitative ones as mean (SD).

TABLE 2. Differences Between Ultrasound Variables at Discharge and Values of NT-proBNP on Admittance and at Discharge Among Patients Who Do Not Develop LVR and Those That Undergo LVR

	No Remodeling (n=128)	Remodeling (n=31)	P
E mitral, cm/s	80 (17)	84 (21)	.58
A mitral, cm/s	77 (22)	79 (27)	.11
E/A	1.1 (0.4)	1.2 (0.8)	.005
TDE, ms	195 (50)	181 (59)	.32
TRIV	106 (22)	108 (28)	.26
Vp, cm/s	46 (17)	51 (25)	.14
E/Vp	2 (0.8)	1.9 (0.9)	.77
Sm, cm/s	7.1 (1.3)	6.4 (1.7)	.043
Em, cm/s	6.5 (1.5)	5.2 (1.5)	.64
Am, cm/s	77 (22)	79 (27)	.61
E/Em	13 (4.2)	17.9 (8.5)	.001
LAV indexed, mL/m ²	28 (8)	30 (10)	.014
LVEDV indexed, mL/m ²	56 (11)	57 (15)	.019
LVESV indexed, mL/m ²	23 (10)	28 (13)	.027
EF, %	60 (11)	53 (13)	.14
Mitral reflux			
No	111 (87%)	24 (77%)	.364
ORE <0.20 cm ²	13 (10%)	6 (19%)	
ORE ≥0.20 cm ²	4 (3%)	1 (3%)	
NT-proBNP on admittance, pg/mL	374 (799)	460 (941)	.66
NT-proBNP at discharge, pg/mL	945 (1630)	1957 (2000)	.016

Am indicates septal mitral ring A-velocity; E/A, ratio between E and A mitral filling velocities; EDT, mitral E wave deceleration time; EF, ejection fraction; Em, septal mitral ring E-velocity; EROA, effective regurgitant orifice area; LAV, left atrial volume; LVEDV, left ventricle end of diastole volume; LVESV, left ventricle end of systole volume; LVIVRT, left ventricle isovolumetric relaxation time; Sm, septal mitral ring S-velocity; Vp, colour M-mode Doppler propagation velocity of early mitral filling.

[1630] pg/mL; $P=.016$). This difference was not seen in NT-proBNP values measured before the PCI.

When the echocardiographic variables associated with remodeling and NT-proBNP values at discharge

are used in a logistical regression analysis, the only parameter that continued to be an independent predictor was the E/Em ratio (OR, 1.143; 95% CI, 1.039-1.258; $P=.006$). The operator-receptor

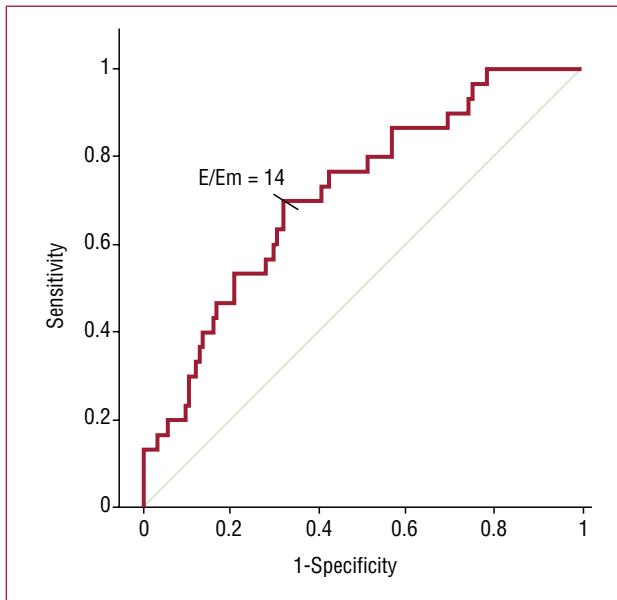


Figure 1. ROC curve for E/Em levels on discharge in relation to development of LVR. Area under the curve: 0.72 (95% IC, 0.62-0.82; $P=.001$).

characteristics (ORC) curve was calculated to provide a better estimate of the best cut-off point for the E/Em ratio to predict LVR (Figure 1). Area under the curve was 0.72 (95% CI, 0.62-0.82; $P=.001$) and the E/Em value that most exactly predicted LVR was 14, with a sensitivity of 70% and a specificity of 68%. In Figure 2 it is possible to see how in those patients that an E/Em ≥ 14 there were more cases of EDV increase, whereas most of the patients with an E/Em <14 had an EDV that remained stable during their evolution.

Table 3 shows echocardiographic variables and NT-proBNP values measured at 6 months. Those patients who underwent LVR not only had a greater left ventricular EDV (54 mL/m² vs 75 mL/m²; $P=.001$) but also a greater ESV, which was doubled (21 [11] mL/m² vs 40 [18] mL/m²), and their EF was reduced (63% vs 49%, $P=.001$). Patients with LVR also had a greater E/Em ratio, a greater LAV and much higher NT-proBNP values at 6 months than patients that did not undergo remodeling.

TABLE 3. Echocardiographic Variables and NT-proBNP Values Measured at 6 Months

	No Remodeling (n=128)	Remodeling (n=31)	P
LVEDV indexed, mL/m ²	54 (13)	75 (18)	.001
LVESV indexed, mL/m ²	21 (11)	40 (18)	.001
EF, %	63 (11)	49 (12)	.001
E/Em	13 (5.3)	17.6 (8.5)	.024
LAV indexed, mL/m ²	31 (9)	38 (13)	.034
NT-proBNP at 6 months, pg/mL	393 (622)	1409 (1967)	.012

EF indicates ejection fraction; Em, septal mitral ring E-velocity; LAV, left atrial volume; LVEDV, left ventricle end of diastole volume; LVESV, left ventricle end of systole volume.

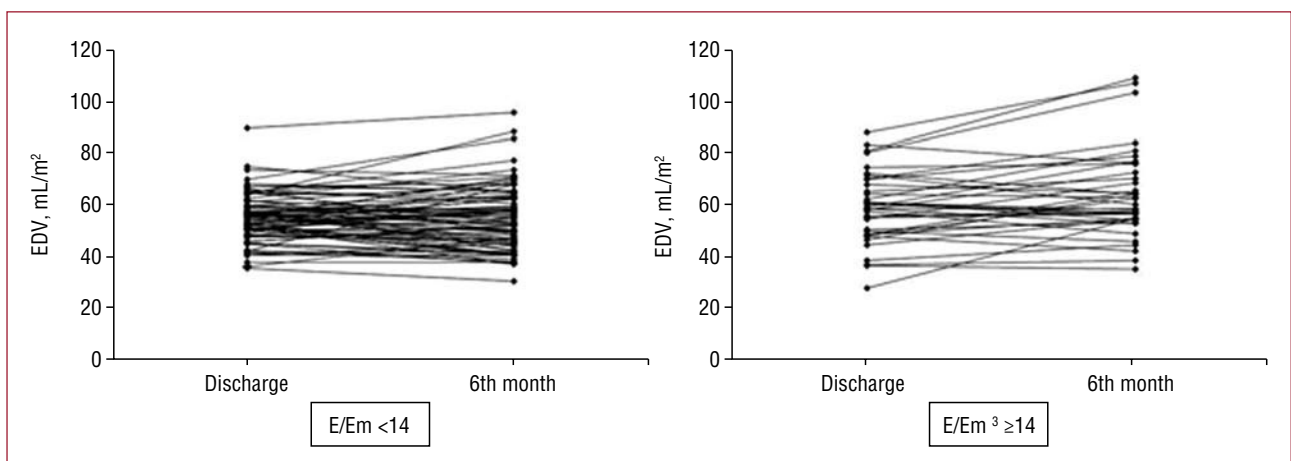


Figure 2. Changes in end-diastolic volume (EDV) in patients with an E/Em ratio <14 and ≥ 14 .

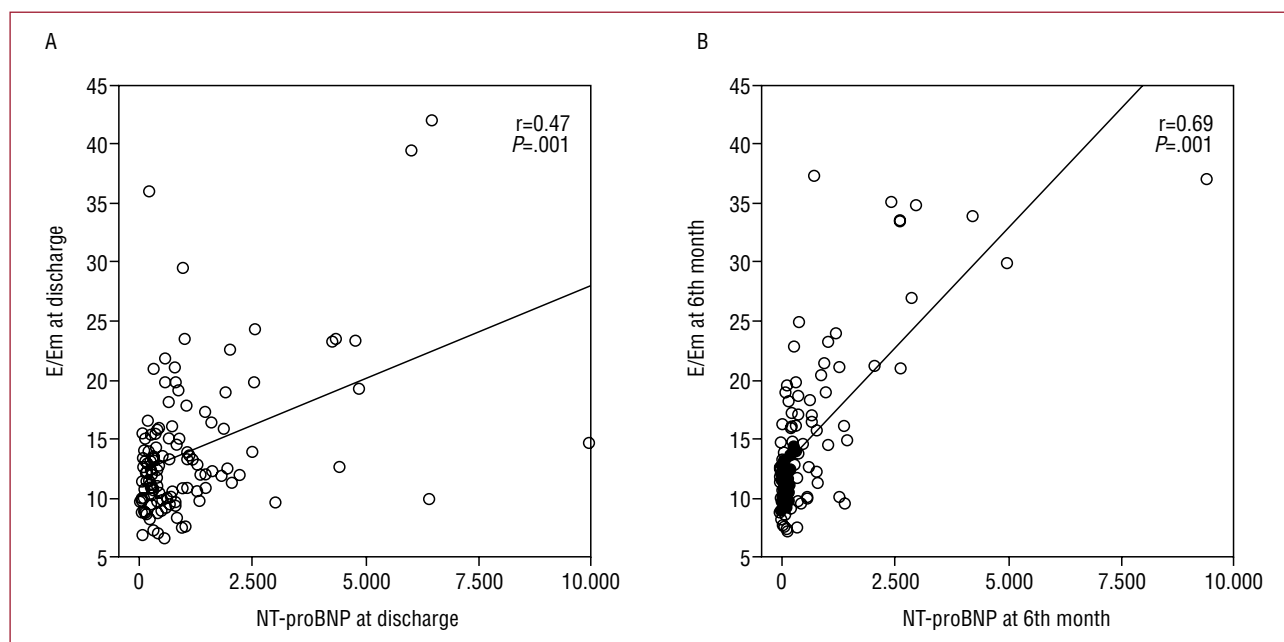


Figure 3. Correlation between E/Em ratio and NT-proBNP at time of discharge (left) and at the 6th month (right).

TABLE 4. Correlation Coefficient (Pearson, r) Between Ultrasound Variables and NT-proBNP on Discharge and at 6 Months

	NT-proBNP on Discharge		NT-proBNP at 6 Months	
	r	P	r	P
LVEDV indexed	0.49	.001	0.47	.001
LVESV indexed	0.61	.001	0.64	.001
EF	-0.41	.001	-0.49	.001
E/A	0.33	.001	0.55	.001
TDE	-0.11	NS	-0.23	.043
E/Em	0.47	.001	0.69	.001
LAV indexed	0.17	.09	0.43	.001

E/A: indicates ratio between E and A mitral filling velocities; EDT, mitral E wave deceleration time; EF, ejection fraction; Em, septal mitral ring E-velocity; LAV, left atrial volume; LVEDV, left ventricle end of diastole volume; LVESV, left ventricle end of systole volume.

Correlation Between NT-proBNP and Echocardiographic Variables

We studied the correlation between NT-proBNP and echocardiographic variables at 2 moments in time after STEAMI: at discharge (subacute phase) and at 6 months (chronic phase). Table 4 shows the values of the different correlations, quantified using a Pearson r coefficient. Both during the subacute and the chronic phase after STEAMI there was a similar correlation of NT-proBNP with left ventricle volumes and ejection fraction, which was more intense for ESV ($r=0.61$ and 0.64 at discharge and 6

months, respectively). When the correlation of NT-proBNP with echocardiographic parameters that estimate left filling pressure was analyzed, it was seen that there was no correlation between LAV and US at discharge, whereas during the chronic phase there was a correlation, although minor ($r=0.47$; $P=.001$). There was correlation of the E/Em ratio and NT-proBNP both at discharge and at 6 months; a more intense correlation was noted during the chronic phase than at discharge ($r=0.69$ vs $r=0.47$ respectively) (Figure 3).

Intraobserver Variability

To analyze intraobserver variability we took the first 15 patients, in whom the echocardiographer quantified left ventricular EDV and left ventricular ESV, as well as the E/Em ratio on 2 different days. The second measurement of each variable was blind with reference to the first measurement. Intraobserver variability for EDV was 5%, for ESV was 4% and for E/Em was 4%.

DISCUSSION

NT-ProBNP and Echocardiographic Variables: Usefulness as Predictors of Left Ventricular Remodeling

In our cohort, when analyzing echocardiographic measurements together with NT-proBNP values on admittance and at discharge, the only independent

predictor for remodeling was the E/Em ratio. It is well known that among the pathophysiological mechanisms that cause remodeling after infarction, the alteration of the diastolic properties of the ventricle plays a fundamental role.¹⁴ Echocardiography is a widely available technique that makes it possible to assess diastolic function non-invasively. Before the use of tissue Doppler it was already known that a shortening of early mitral filling deceleration time was a predictor of remodeling.¹⁵ Subsequently, with the use of tissue Doppler, and concretely, measurement of the E/Em ratio, we have been able to estimate ventricular filling pressure with less dependency on loading conditions. An E/Em ratio >15 seems to identify patients with high left filling pressure.¹⁶ However, the usefulness of the E/Em ratio to estimate ventricular filling pressure has its limitations. There is also a “grey area” when the E/Em ratio is between 8 and 15.¹⁶ This has been described as less exact in those patients with preserved EF (>50%).¹⁷ The objective of our study was not to assess the correlation of the E/Em ratio with ventricular filling pressures, but to determine the usefulness of this ratio in the prediction of LVR subsequent to STEAMI. We found that the E/Em ratio was an independent predictor for LVR. The E/Em value which most exactly predicted LVR was 14. Hillis et al found in a series of 47 patients with infarction that the septal E/Em ratio was the main remodeling predictor,¹⁸ with 15 being the best cut-off point, which is a value close to the one determined in our study. For our study's E/Em value of 14, sensitivity and specificity were 70% and 68% respectively, not optimum figures. This indicates that, as is the case for the determination of left filling pressure, there is a “grey zone” for the use of the E/Em ratio as a predictor of LVR.

As was seen in other studies,¹⁹ patients in our series who underwent LVR had higher levels of NT-proBNP at hospital discharge. However, there was no such association between LVR and NT-proBNP measured on admittance. This difference has been seen in studies showing that the best moment to determine the value of NT-proBNP with a greater predictive power of death or ventricular dysfunction after infarction, is not at admittance but on the 3rd and 5th day after infarction.²⁰

Few studies have analyzed the predictive value for LVR after STEAMI of NT-proBNP analyzed together with echocardiographic variables. Cerisano et al found that deceleration time of the mitral E wave is better than BNP at predicting remodeling after infarction.⁷ However, this superiority of Doppler studies in comparison with determination of BNP values has not been documented in other studies.²¹ Our study was the first to compare the E/Em ratio with NT-proBNP values to predict remodeling

after STEAMI, and found that E/Em was the best predictor. An explanation of this could be that NT-proBNP values after infarction are not only elevated due to stretching of the myocytes caused by high filling pressures, but also due to ischemia.⁴

Ischaemic mitral failure after infarction has been found to be prognostic of remodeling.²² However, in our series the presence of high mitral failure did not predict LVR. Ennezat et al saw that after infarction the presence of echocardiographically detected mitral regurgitation was not associated with remodeling, whereas there was association when mitral regurgitation was quantified at 3 months after infarction.²³

Correlation of NR-proBNP and Echocardiographic Variables Before Discharge and During the Chronic Phase After STEAMI

Our study was the first to compare the correlation between natriuretic peptide levels and echocardiographic variables that quantify ventricular function at different points in time after infarction. In our series the correlation of NT-proBNP with EF and left ventricular volumes was similar at discharge and during the chronic phase. Of all these variables, the strongest correlation was seen, both during the subacute phase and the chronic one, for ESV. Other studies have also described the closer correlation between BNP and ESV.²⁴ The correlation of NT-proBNP with echocardiographic variables that quantify left filling pressure, especially E/Em and LAV, was better during the chronic phase than the subacute one subsequent to infarction. LAV did not show any correlation with NT-proBNP during the subacute phase, whereas it did during the chronic phase, although this was not intense. This difference probably is due to the fact that during the subacute phase insufficient time has elapsed for the elevation of filling pressure to dilate the atria. The E/Em ratio, which reflects left filling pressure at the time of the study, showed a correlation with NT-proBNP both during the subacute and the chronic phase. However, this correlation was greater during the chronic phase ($r=0.69$) than at discharge ($r=0.47$). A possible explanation for this observation may be that NT-proBNP values during the subacute phase are not only influenced by ventricular filling pressure, but also by ischemia. Therefore, in contrast to the E/Em ratio, NT pro-BNP is rather a marker of heart disease than of an increase in left filling pressure.²⁵

It must be highlighted that among those patients that did not undergo LVR there was a lower percentage of smokers. It is evident that smokers are at greater risk of infarction and cardiovascular death. However, several studies have shown that

smokers suffer less mortality after a STEAMI, especially if they undergo reperfusion therapy.^{26,27} This fact, described as the “tobacco paradox,” has generally been explained by the fact that tobacco acts as a “confusion factor” because smokers are usually younger and have fewer associated risk factors.²⁷ However, some authors consider the possibility that there is less microvascular damage in smokers.²⁸

Limitations

This study is based on a surrogate objective, i.e. LVR, instead of using clinical end-points such as death or heart failure, for which it would have been necessary to carry out a longer follow-up to obtain results.

The patients in our series had a normal mean EF before discharge (58%), although a quarter of them had a reduced EF (<50%). The use of primary PCI as reperfusion treatment probably contributed to the fact that patients had a good EF at discharge. Furthermore, as the objective was LVR at 6 months, those patients that died during this interval of time were excluded, as were those that suffered reinfarction or restenosis. It is also possible that not all the patients that suffered STEAMI and came to hospital were considered for primary PCI by the Emergency Service physicians, and this treatment could have been ruled out for patients at greater risk, such as the elderly. All this limits the extrapolation of the results obtained in our series to the general population that suffers a STEAMI.

The number of patients that underwent LVR was not high and this could limit the statistical power to find remodeling predictors.

Only those patients that had a clinical recurrence of ischaemia had a repeat catheterization. The protocol did not include a control catheterization at 6 months in all patients to ensure that, in spite of the lack of symptoms, the remodeling was not due, in part, to restenosis or progression of coronary disease.

CONCLUSIONS

Of many echocardiographic variables determined at discharge in patients that have suffered a STEAMI, are treated with PCI and have no complications during hospitalisation, the E/Em ratio is the best predictor of LVR. NT-proBNP at discharge, although it is associated with the development of remodeling, is not an independent predictive factor when considered together with echocardiography. NT-proBNP showed similar correlation with left ventricular volumes and EF during the subacute and the chronic phases. However, correlation of NT-proBNP with echocardiographic variables that quantify left filling pressure, such as E/Em and LAV,

was better during the chronic phase than during the subacute phase subsequent to infarction.

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