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CME

Serum Markers, Conventional Doppler Echocardiography and Two-dimensional Systolic Strain in the Diagnosis of Chemotherapy-Induced Myocardial Toxicity*

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ABSTRACT

Background
Left ventricular dysfunction is a serious complication of antineoplastic treatment with unfavorable impact in future clinical outcome. Early diagnosis of cardiotoxicity in patients receiving chemotherapy might be useful to define a strategy for the prevention of ventricular function impairment.

Objective
The aim of this study was to analyze the usefulness of serum markers (troponin T (TnT), BNP and NT-proBNP) and two-dimensional systolic longitudinal (LS) and radial (RS) strain to detect ventricular systolic dysfunction in patients treated with cardiotoxic chemotherapy.

Methods
Thirty six patients (average age (±SD) 47±16 years, 42% men), with neoplastic disease with normal myocardial mass and left ventricular ejection fraction (LVEF) ≥55% receiving chemotherapy treatment, were prospectively included. Assessment of serum markers and echocardiography were performed before chemotherapy and at 2, 3, 4 and 6 months after onset of cancer treatment. The 6-month cardiotoxicity endpoint (EP) was defined as reduced LVEF according to international consensus.

Results
Seven patients reached the EP (19.4%). Endpoint predictors were: NT-proBNP at 4 months (positive EP (G1): 152 ±42 pg/ml vs. negative EP (G2) 61±38 pg/ml, p< 0.001), BNP at 4 months (G1 41±12 pg/ml vs. G2 26±11 pg/ml, p< 0.01), two-dimensional LS at 3 months (G1 16.3±2.4% vs. G2 19.6±2.02%, p< 0.01) and 4 months (G1 15.9±1.77% vs. G2 19.9±2.2%, p< 0.001), and two-dimensional RS at 4 months (G1 46.4±2.4% vs. G2 52±3.4%, p< 0.001).

Conclusions
Natriuretic peptides and two-dimensional systolic LS and RS were useful to predict mild ventricular systolic dysfunction in chemotherapy-treated patients.

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Key words > strain imaging, chemotherapy, cardiotoxicitiy

Abbreviations >

BNP:	brain natriuretic peptideNT- pro	**EP:**	endpoint
BNP:	N-terminal fraction of the brain natriuretic peptide		G1 Group 1 (cardiotoxicidad +)
			G2 Group 2 (cardiotoxicidad –)
MWSF:	Midwall shortening fraction	**LS:**	Two-dimensional longitudinal strain
LVEF:	Left ventricular ejection fraction	**RS:**	Two-dimensional radial strain TnT Troponin T

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INTRODUCTION

Left ventricular dysfunction is a serious complication of chemotherapy treatment with unfavorable impact in future clinical outcome. Moreover, improved therapeutic options to treat cancer determine a growing number of surviving patients who will suffer the consequences of structural myocardial injury. (1)

There are numerous studies describing the incidence of myocardial injury assessed by a heart pump parameter as left ventricular ejection fraction (LVEF) (2-4) because, although endomyocardial biopsy is a sensitive methodology, its invasiveness prevents a systematic indication. (5)

There are limited clinical studies on biochemical predictors. (4, 5) Many studies suggest that troponin T (TnT) is an early marker of myocardial injury in patients submitted to cardiotoxic therapy. (6-9) Moreover, some studies, analyzing the importance of natriuretic peptides as predictors of ventricular dysfunction have reported dissimilar results. (10-12)

Left ventricular ejection fraction is an inadequate pump function parameter for the detection of small left ventricular function changes. We hypothesize that slight alterations of myocardial deformation as expression of myocardial injury could be detected prior to reduction of LVEF.

The purpose of this study was thus to assess the relationship between two-dimensional strain and LVEF during chemotherapy treatment and to determine whether early serial ecocardiographic measurements of myocardial deformation and serum markers: quantitative TnT, brain natriuretic peptide (BNP), and the N-terminal fraction of the brain natriuretic peptide (NT-proBNP) could predict cardiotoxicity.

METHODS

Thirty six patients (mean age (±SD) 47±16 years, 42% men) with neoplastic disease and normal myocardial mass, LVEF ≥55%, no history of cardiovascular diseases and sinus rhythm were prospectively included to receive potentially cardiotoxic chemotheraphy. All patients complied with the informed consent process and the study was approved by the institutional research committee.

Physical examination, assessment of serum markers (TnT, BNP, NT-proBNP) and Doppler ultrasound were performed in basal conditions and at 2, 3, 4 and 6 months after onset of cancer treatment.

Exclusion criteria were: age < 18 years, cardiovascular disease, creatinine >1.5 mg/dl, liver disease, LVEF < 55%, inadequate ultrasound window and left bundle branch block.

Systolic dysfunction, defined as a 5 point decrease in LVEF < 55% in symptomatic patients or a 10 point decrease in LVSF < 55% in asymptomatic patients, was considered as 6 month-cardiotoxicity endpoint (EP) parameter. (13)

Biochemical assessments

Blood samples were stored at -70º C and the results were kept blinded until the end of the study.

N-terminal-proBNP levels were determined by immunoassay (Elecsys 2010, Roche Diagnostics), with analytical range from 5 to 35000 pg/ml (3% coefficient of variation).

A chemiluminiscent microparticle immunoassay (ARCHITECT BNP assay, CMIA, Abbott Diagnostics) was used to determine BNP levels.

Troponin T levels were measured with a third generation immunoassay method (Elecsys 2010, Roche Diagnostics), with analytical range from 0.01 to 25 ng/ml (7.65% coefficient of variation).

The analyses were performed by specialized technical staff blind to patient characteristics.

Echocardiographic analysis

A Vivid 7 echocardiograph (General Electric) was used with a 3.5 MHz transducer and the EchoPACS work station was employed for off-line analysis by two independent operators. Echocardiographic images of 3 cardiac cycles were acquired following standard technique. Left ventricular ejection fraction was calculated by one operator from apical two and four-chamber view images using the Simpson method. The rest of the measurements were performed by another operator blind to LVEF result. Both operators were blind to patient cancer treatment and study sequence. Midwall shortening fraction (MWSF) was calculated according to the formula described by Shimizu. (15)

Two-dimensional color tissue Doppler imaging (TDI) (frame rate > 100) was saved in cine-loop format, and off-line pulsed TDI was performed to assess regional systolic behavior by averaging lateral and septal mitral annulus images.

The "speckle tracking" technique was used to determine myocardial deformation (two-dimensional strain) from a parasternal short axis view at papillary muscle level (radial strain (RS), average of 6 segments) and apical two and four-chamber views (longitudinal strain, (LS)). The two-dimensional LS was determined as the average basal and mid-segment deformation of the anterior, inferior, septal and lateral wall. Longitudinal strain assessment was simplified because 10 patients had left breast surgery which obstructed standard acquisition of apical views. The image was digitized at a rate of > 50 frames/s, adjusting it to 80% heart rate. (16)

Statistical analysis

Intraobserver and interobserver variability in two-dimensional strain calculation was reported as mean ± SD error analysis. Absolute values of intraobserver and interobserver variability were: -0.20±1.1% and -0.6±1.4% for LS and 3.2±6.6% and 3.4±7.1% for RS, respectively.

Discrete variables were expressed as frequencies and percentages and continuous variables as mean and standard deviation. Qualitative variables were compared using the chi-square test with Yates correction or Fischer´s exact test. Independent continuous variables were analyzed using unpaired Student´s t test or Wilconxon´s rank sum test as appropriate. Paired continuous variables were assessed with ANOVA for repeated measures. ROC curves were used to determine cut-off values to calculate sensitivity and specificity. A p value < 0.05 was considered statistically significant.

RESULTS

Thirty six patients were included in the study, 7 (19.4%) of which presented cardiotoxicity criteria. Four patients were excluded for inadequate test quality. There were no differences in basal variables (Table 1). Regarding type of tumor and treatment received, there was greater indication and higher dose of adriamycin in patients who developed the primary endpoint (Table II).

Longitudinal follow-up showed significant decreased LVEF and systolic radial and longitudinal strain, and increased systolic end-diastolic volume and NT-proBNP (Table III).

There were no significant differences in clinical, echocardiographic and biochemical marker variables. Table IV shows volume, ventricular systolic and diastolic function, myocardial deformation and serum marker parameters according to presence of cardiotoxicity.

Follow-up serum marker dosage only detected significant differences between G1 (cardiotoxicity (+)) and G2(cardiotoxicity (-)) in NT-proBNP at 4 months (G1 152 ±42 pg/ml vs. G2 61±38 pg/ml, p<0.001), and 6 months (G1 159±53 pg/ml vs. G2 62±38 pg/ml, p<0.001), and in BNP at 4 months (G1 41±12 pg/ml vs. G2 26±11 pg/ml, p<0.01), and 6 months (G1 52±20 pg/ml vs. G2 25±11 pg/ml , p<0.001). To detect 6-month systolic dysfunction, a 4-month NT-proBNP cut-off value of 97 pg/ml had 85% sensitivity and 86% specificity (AUC: 0.95, CI: 0.88-1.03, positive likelihood ratio: 6.2 and negative likelihood ratio: 0.17) and a 4-month BNP cut-off value of 31 pg/ml had 86% sensitivity and 79% specificity (AUC: 0.83, CI: 0.64-1.01, positive likelihood ratio: 4.1 and negative likelihood ratio: 0.18).

Percentage of deformation evidenced significant differences between G1 and G2 at the longitudinal level at 3 months (G1 -16.3±2.4% vs. G2 –19.6±2.02%, p<0.01), 4 months (G1–15.9±1.77% vs. G2–19.9±2.2%, p<0.001) and 6 months (G1 –15.3±1.5% vs. G2 –20±2.04%, p<0.001) and at the radial level at 4 months (G1 46.4±2.4% vs. G2 52±3.4%, p<0,001) and 6 months (G1 44±4.5% vs. G2 51±3.1%, p<0.001). To detect systolic dysfunction at 6 months, LS reduction cut-off value ≥ 15% at 3 months had 86% sensitivity and 86% specificity (positive likelihood ratio: 6.21 and negative likelihood ratio: 0.17), RS reduction cutoff value ≥ 10% at 4 months presented 86% sensitivity and 69% specificity (positive likelihood ratio: 2.76 and negative likelihood ratio: 0.21), and the combination of both strains at 4 months had 71% sensitivity and 97% specificity (positive likelihood ratio: 21 and negative likelihood ratio: 0.3).

DISCUSSION

Left ventricular ejection fraction is a strong predictor of long-term outcome in surviving patients treated with chemotherapy, and has been the standard parameter to assess ventricular systolic function at the onset of treatment and after treatment. (17) Periodic ventricular function monitoring is essential for the early detection of left ventricular dysfunction and echocardiography is the method of choice for sequential evaluation, though the American Heart Association does not specify the method, thresholds or time intervals for the adult population. (18-20)

Seven patients (19.4%) presented with cardiotoxicity criteria without symptoms during follow-up, with prevalence similar to that reported in other studies that only included patients treated with anthracyclines and trastuzumab. (4-6)

In the present work, with a population suffering from different types of cancer treated with cardiotoxic drugs, reduced myocardial deformation, increased BNP and NT-proBNP and the E/e' ratio during intensive early follow-up detected left ventricular dysfunction prior to volume alterations and reduced performance and functional indexes.

In a mice model of myocardial injury by anthracyclines, decreased strain rate as a contractility marker predicted late reduction of LVEF and mortality. (21)

Table 1. Patient baseline characteristics

Variables	Cardiotoxicity		p value
	Present (n=7, 19.4%)	Absent (n=29, 80.6%)	
Age (years)	53±14	45±16	0.23
Male gender	4 (57.1)	11 (37.9)	0.36
Heart rate (beats/min)	67±8	68±16	0.92
Systolic blood pressure (mm Hg)	120±5	117±28	0.78
Diastolic blood pressure (mm Hg)	68±8	68±17	0.95
Body surface (m2)	1.81±0.05	1.78±0.11	0.65
Height (meters)	1.71±0.09	1.65±0.07	0.06
Prior cardiotoxic chemotherapy treatment	1 (14.3)	8 (28)	0.47
Prior radiotherapy treatment	1 (14.3)	5 (17.2)	0.85
Cardiac risk factors			
Diabetes mellitus	0 (0)	2 (6.9)	1
Hypertension (>140/90 mm Hg)	1 (14.3)	8 (28)	0.47
Smoking	4 (57.1)	11 (37.9)	0.4
Hypercolesterolemia (>200 mg %)	0 (0)	7 (24.1)	0.3
Antihypertensive treatment			
Angiotensin-converting enzyme inhibitors	0 (0)	7 (24.1)	0.3
Calcium blockers	1 (14.3)	1 (3.4)	0.9

MRS: Myocardial revascularization surgery; ns: non significant

In patients treated with anthracyclines/trastuzumab, Sawaya et al. found that reduction of LS at 3 months and ultrasensitive cardiac troponin I at 3 months were independent predictors of cardiotoxicity defined with the same criteria used in this work. Left ventricular ejection fraction, diastolic function parameters and NT-proBNP did not predict cardiotoxicity. (10) Moreover, Ganame et al. and Jurcut et al. observed reduction in peak systolic LS and RS during anthracycline treatment, (22, 23) different from Hare et al. (24) who reported no reducted myocardial strain following trastuzumab therapy.

Stoodley et al (25) analyzed peak systolic LS, RS and circumferential strain behavior one week pre and post treatment and observed earlier reduction of global (> 10% reduction in 48% of patients) and regional LS and of global (> 10% reduction in 59% of patients) and regional RS. At the American Society of Echocardiography Annual Scientific Sessions (2012), Pignatelli et al confirmed the LS value defined by SD ± 2 in the Z score adjusted by age to predict ventricular dysfunction in a pediatric population treated with chemotherapy. (26)

In other clinical settings a reduction in global LS has been reported in patients with preserved LVEF. (27-29) One of the main findings of our work suggests that LS is more sensitive than LVEF to detect early changes in ventricular function even when compared to functional parameters adjusted by stress (MWSF / circumferential stress) and increased volumes. Moreover, similarly to Stoodley et al.´s results (25), LS may precede global RS changes.

Left ventricular anatomy is a complex structure formed by three muscular layers classified not as dif-

Table 2. Description of cancer treatment

	Cardiotoxicity	
	Present (n=7, 19.4%)	Absent (n=29, 80.6%)
Primary site		
Breast	2 (28.6)	14 (48.6)
Lymphoma/Leukemia	3 (42.9)	8 (28)
Others	2 (28.6)	7 (24)
Chemotherapy treatment		
Doxorubicin (adriamycin)	7 (100)	14 (48.3)*
Dose (mg/m2)	294±122	102±124*
Trastuzumab	2 (28.6)	6 (20.7)
Mitoxantrone	0 (0)	1 (3.4)
Platinum	2 (28.6)	7 (24)
Cyclophosphamide	5 (71.4)	10 (34.5)
Citarabine	0 (0)	1 (3.4)
5´fluorouracil	0 (0)	5 (17.2)
Taxanes	3 (42.9)	10 (34.5)
Etoposide	1 (14.3)	0 (0)
Vincristine	2 (28.6)	0 (0)
Bevacizumab	0 (0)	1 (3.4)
Bleomycin	0 (0)	5 (17.2)

*P <0.05

Table 3. Description of clinical, echocardiographic and serum biomarker characteristics in the 36 patients, before and after chemotherapy treatment.

p value	Basal	2nd month	3rd month	4th month	6th month	p value
End-diastolic volume (ml)	81±17	85±14	82±15	87±14	87±14.3	<0.05
LVEF	65±7	64±5	63.5±5.1	64.5±5.6	64±5.5	<0.05
MWSF/Circumferential stress	18.83±0.77	16.78±0.53	16.69±0.54	16.73±1.23	16.77±1.09	NS
Radial strain (%)	53.1±4	52.6±3	53±2.9	50±3.9	49.9±4	<0.001
Longitudinal strain (%)	-20.3±2.7	-19.8±2.2	-18.9±2.5	19±2.6	19±2.7	<0.005
Left atrium (ml/m2)	26±4	27±5.6	27.1±3.8	27±4.9	28.3±6.8	NS
Mitral E velocity (m/seg)	0.81±0.17	0.80±0.17	0.77±0.16	0.78±0.18	0.82±0.19	NS
Mitral E/A ratio	1.5±0.4	1.48±0.46	1.44±0.45	1.43±0.46	1.4±0.48	NS
Desacceleration time of the E wave (seg)	221±39	236±41	234±40	228±40	229±40	NS
Mitral annular s-wave velocity (cm/seg)	13.3±5.7	11±2.3	10.5±2.4	10.7±2.2	10.8±2.2	NS
Mitral annular e-wave velocity (cm/seg)	13±2.4	11.9±2.4	11.5±2.7	11.2±2.2	11 ±2.3	NS
E/e´ ratio	6.9±1.9	7.1±2.6	7.4±3.2	7.1±3.2	7.6±2	NS
BNP (pg/ml)	23±9	22±10	34±38	31±20	28±16	0.06
NT-proBNP(pg/ml)	53±20	54±22	58±32	81±71	79±66	<0.05
TnT (ug/ml)	0.012±0.005	0.019±0.048	0.012±0.006	0.0119±0.005	0.0111±0.003	NS

BNP: brain natriuretic peptideNT- proBNP: N-terminal fraction of the brain natriuretic peptide. MWSF: Midwall shortening fraction. LVEF: Left ventricular ejection fraction. EP: endpoint. G1 Group 1 (cardiotoxicidad +). G2 Group 2 (cardiotoxicidad –). LS: Two-dimensional longitudinal strainRS: Two-dimensional radial strain. TnT Troponin T.

Table 4. Systolic and diastolic ventricular function parameters and serum biomarkers in the presence or absence of cardiotoxicity.

Variables	Basal	3rd month	4th month	6th month
Ejection fraction				
Cardiotoxicity +	64±2	61±2	61±1.4	51.7±2
Cardiotoxicity -	63±6	64±4.7	64±4	63±3.6
p value	ns	ns	ns	0.0001
End-diastolic volume				
Cardiotoxicity +	77±21	75±22	87±19	87±19
Cardiotoxicity -	83±15	84±13	87±13	87±13.4
p value	ns	ns	ns	ns
End-systolic volume				
Cardiotoxicity +	28±7	29.6±9	36.9±9	41.9±9.1
Cardiotoxicity -	30±8	30±5.6	31±6.2	32±6
p value	ns	ns	ns	0.001
MWSF				
Cardiotoxicity +	17.1±2.4	16.8±2.7	17.8±4.2	15±2
Cardiotoxicity -	18.5±2.8	17.5±2.4	16.9±2.5	17.2±2.5
p value	ns	ns	ns	0,01
MWSF/circumferential stress				
Cardiotoxicity +	16.8±0.24	16.6±0.5	16.8±0.91	16±0.64
Cardiotoxicity -	16.8±0.85	16.7±0.6	16.7±1.3	17.2±1.2
p value	ns	ns	ns	0.01
E/e´ ratio				
Cardiotoxicity +	7.6±7.6	10±5.9	9±1.6	8.9±2.7
Cardiotoxicity -	6.8±1.8	6.7±1.6	6.7±1.7	6.6±1.3
p value	ns	0.005	0.03	0.04
Longitudinal Strain				
Cardiotoxicity +	-20.4±3	-16.3±2.4	-15.9±1.7	-15±1
Cardiotoxicity -	-20.2±2.7	-19.6±2	-19.9±1.9	20.3±2
p value	ns	0.001	0.0001	0.0001
Radial Strain				
Cardiotoxicity +	54±2	51±4	46±2	44±4
Cardiotoxicity -	53±4	53±3	52±3	51±3
p value	ns	ns	0.001	0.001
BNP				
Cardiotoxicity +	23±6	37±36	41±12	51±13
Cardiotoxicity -	23±10	24±18	26±11	25±11
p value	ns	ns	0.001	0.001
NT-proBNP				
Cardiotoxicity +	55±14	82±35	152±42	159±53
Cardiotoxicity -	47.5±17	64±34	61±38	62±38
p value	ns	ns	0.001	0.001

BNP: brain natriuretic peptideNT- pro. BNP: N-terminal fraction of the brain natriuretic peptide.
MWSF: Midwall shortening fraction

ferent muscular groups but according to the predominant myocyte orientation. Left ventricular ejection fraction measures global function, but is unable to analyze the injured layer. In this sense, two-dimensional strain may analyze not only regional injury but also subendocardial, mesocardial and epicardial fiber behavior and, different from strain determined by tissue Doppler, it allows low frame frequency, with high reproducibility and no angle dependence. (30, 31)

Early systolic LS alteration and lower variability than RS favor its use to monitor cardiotoxicity. Recently, Fallah-Rad et al. reported a significant reduction in LS and RS after anthracycline treatment in patients developing cardiotoxicity following trastuzumab treatment. (32) Tsai et al. observed reduced SL without changes in circumferential strain and LVEF in surviving cancer patients treated with anthracyclines and/or radiotherapy. (33) In another study, Ho et al. found reduced LS in a group of patients treated with anthracyclines and in a subgroup who received trastuzumab. (34)

Cardinale et al. detected troponin I increase in 33% of patients after treatment with high anthracycline dosage, although more recent reports have shown lower troponin I increase and no predictive value for reduced LVEF. (9, 35) In the present work,

quantitative troponin T analysis did not predict LVEF reduction, different from Sawaya´s study (10) where ultrasensitive troponin I increased in 28% of cases at 3 months and predicted a reduction in LVEF in 2/3 of patients. Probably, new ultrasensistive troponins will sensitize early detection of myocardial injury and improve cardiotoxicity assessment.

There are numerous studies analyzing early diastolic function involvement after chemotherapy treatment. (36, 37) In a study which included 26 acute leukemia patients treated with anthracyclines, early diastolic dysfunction was observed before reduced LVEF. (38) Stoddard et al. observed prolongation of isovolumic relaxation time after 3 weeks of cumulative doses of doxorubicin prior to development of systolic dysfunction. (39) Stoodlye et al. (40) reported that altered early diastolic strain rate correlated with decreased LS following cancer treatment and with reduced LVEF, although the two-dimensional strain was the only independent predictor of cardiotoxicity. We observed sequential reduction of the mitral annulus tissue "e" wave and increased E/e´ ratio in the group presenting cardiotoxicity. The NT-proBNP and BNP levels at 4 months were predictors of posterior LVEF reduction. Values of elevated biomarkers and E/e´ ratio are lower than those observed in heart failure patients and could be representative of initial increased values in patients with mild systolic dysfunction. In a population without myocardial injury assessed by quantitative troponin, the mechanism producing two-dimensional strain alterations with increased natriuretic peptides and E/e´ratio is speculative. This behavior contradicts Sawaya et al´s study, reporting troponin as predictive marker of left ventricular dysfunction, with sequential reduction of tissue E wave, and without changes in tissue E/e´ ratio and NT-proBNP.

Reduced myocardial deformation calculated by LS > 15% at 3 months and NT-proBNP > 97 pg/ml at 4 months, identified 100% of patients with cardiotoxicity.

Limitations

The study included a limited number of patients, similarly to international series, from one centre only. The 6-month follow-up would require a longer period of time to reveal the predictive values of late clinical events. Sensitivity and specificity should be reproduced in larger prospective studies. Use of quantitative, non-ultrasensitive troponin might have underestimated the predictive value of minimal myocardial injury. The apical window involvement in patients with left breast surgery limited the use of two-dimensional strain in all left ventricular myocardial segments.

CONCLUSIONS

Two-dimensional systolic LS and RS and natriuretic peptides were used to predict mild systolic dysfunction in patients treated with potentially cardiotoxic chemotherapy. Early identification of myocardial injury does not entail treatment interruption, but could be useful to select a cardioprotective medication, perform more frequent monitoring or eventually modify the therapeutic plan.

RESUMEN

Integración de marcadores humorales, ecocardiograma Doppler convencional y strain bidimensional en la detección de toxicidad miocárdica secundaria a la quimioterapia

Introducción
La disfunción ventricular izquierda es una complicación grave del tratamiento antineoplásico, con impacto desfavorable en la evolución clínica futura. El diagnóstico precoz de cardiotoxicidad en pacientes que reciben quimioterapia podría ser de utilidad para definir una estrategia de prevención del deterioro de la función ventricular.

Objetivo
Analizar la utilidad de marcadores humorales [troponina T (TnT), BNP y pro-BNP] y del strain bidimensional longitudinal (SBL) y radial (SBR) para la detección de disfunción ventricular sistólica en pacientes tratados con quimioterapia cardiotóxica.

Material y métodos
Se incluyeron forma prospectiva 36 pacientes, edad promedio (± DE) de 47 ± 16 años (42% hombres), con enfermedad neoplásica con masa miocárdica normal y fracción de eyección (FEy) ³ 55% tratados con agentes antineoplásicos. Se efectuaron dosajes de marcadores humorales y ecocardiograma basales y al 2.º, 3.º, 4.º y 6.º mes posterior al inicio del tratamiento oncológico. Se consideró punto final (PF) a los 6 meses a la caída de la FEy según consenso internacional.

Resultados
Alcanzaron el PF 7 pacientes (19,4%). Se observaron los siguientes predictores relacionados con el PF: pro-BNP 4.º mes [PF positivo (G1) 152 ± 42 pg/ml vs. PF negativo (G2) 61 ± 38 pg/ml; p < 0,001], BNP 4.º mes (G1 41 ± 12 pg/ml vs. G2 26 ± 11 pg/ml; p < 0,01), SBL 3.º mes (G1 –16,3 ± 2,4% vs. G2 –19,6 ± 2,02%; p < 0,01) y 4.º mes (G1 –15,9 ± 1,77% vs. G2 –19,9 ± 2,2%; p < 0,001) y SBR 4.º mes (G1 46,4 ± 2,4% vs. G2 52 ± 3,4%; p < 0,001).

Conclusiones
El dosaje de péptidos natriuréticos y la medición del strain bidimensional longitudinal y radial fueron de utilidad para predecir disfunción sistólica ventricular de grado leve en pacientes tratados con quimioterapia.

Palabras clave > strain, quimioterapia, cardiotoxicidad.

Conflicts of interest

None declared.

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