Determining factors with regard to physical functional impairment in revascularized patients with acute coronary syndrome

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Summary

Introduction: Functional physical capacity is indirectly associated with mortality, and may be compromised after a cardiovascular event, hence the importance of considering its prognostic factors during treatment in heart disease patients.
Aim: To identify the prognostic factors of functional physical limitation in patients with myocardial revascularization for acute coronary syndrome.
Material and method: A retrospective analysis was carried out of 29 medical records taken from patients submitted to a stress test (Bruce, modified Bruce) after myocardial revascularization during the months of January to December 2019. For the statistical analysis, a univariate and multivariate logistic regression (Odds Ratio-OR) was performed, as well as a simple linear regression analysis between the variables of interest.
Results: the analyzed patients had a mean age of 60 ± 9,2 years, and 76% were men. The presence of systemic arterial hypertension (SAH), lower values of Maximum Heart Rate (HR) (ß = 0,112; CI: 0,074, 0,149; p <0.001), high values of Systolic Arterial Pressure (SBP) (ß = - 0,083; CI 95%: -0,152, -0,014; p <0.020), and a greater number of risk factors (ß = - 1,580; CI 95%: -2,456-0,868; p <0.001), are considered predictors of functional limitation (<7 METs).
Conclusion: The presence of SAH, a greater number of risk factors, as well as high maximum SBP levels and lower maximum HR values reached during the stress test, were shown to be prognostic factors of functional limitation in subjects revascularized for ACS.

Key words:
Rehabilitation. Exercise test. Myocardial ischemia.

Factores determinantes de la limitación física funcional en pacientes revascularizados por síndrome coronario agudo

Resumen

Introducción: La capacidad física funcional se asocia de manera indirecta con la mortalidad, y frecuentemente se ve comprometida después de un evento cardiovascular, de ahí la importancia de considerar sus factores pronósticos durante el tratamiento en los pacientes cardiópatas.
Objetivo: Identificar los factores pronósticos de la limitación física funcional en pacientes revascularizados por Síndrome Coronario Agudo (SCA).
Material y método: Se realizó un análisis retrospectivo de 29 historias clínicas tomadas de pacientes sometidos a una prueba de esfuerzo (Protocolo Bruce o Bruce modificado) posterior a una revascularización miocárdica durante los meses de enero a diciembre del 2019. Para el análisis estadístico se realizó una regresión logística univariada y multivariada (*odds ratio*-OR), así como un análisis de regresión linear simple entre las variables de interés.
Resultados: los pacientes analizados tenían una media de edad de 60 ± 9,2 años, y el 76% fueron hombres. La presencia de hipertensión arterial sistémica (HAS), menores valores de Frecuencia Cardíaca (FC) máxima (ß = 0,112; CI: 0,074, 0,149; p <0,001), altos valores de Presión Arterial Sistólica (PAS) (ß = - 0,083; CI 95%: -0,152, -0,014; p <0,020), y un mayor número de factores de riesgo (ß = - 1,580; CI 95%: -2,456-0,868; p <0,001), son considerados predictores de limitación física funcional (<7 METs).
Conclusión: La presencia de HAS, un mayor número de factores de riesgo, así como altos niveles de PAS máxima y menores valores de FC máxima alcanzadas durante la prueba de esfuerzo, mostraron ser factores pronósticos de la limitación funcional en sujetos revascularizados por SCA.

Palabras clave:
Rehabilitación. Prueba de esfuerzo. Isquemia miocárdica.

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Introduction

The effort test in revascularized patients with coronary artery disease has primarily been used for diagnostic purposes in order to detect residual ischemia, arrhythmias, symptoms and dynamic physiological responses before starting a cardiac rehabilitation programme. Approximately 30% of these programmes conduct effort tests, despite the fact that these tests are considered to be the gold standard for starting rehabilitation. The increase in longevity and in the multimorbidity conditions of the revascularized population, makes its use appear more relevant in order to guide the prescription and progression of pharmacological and physical exercise treatments that are commonly provided to these patients [1,2].

The information commonly extracted during effort tests on this type of patient includes: maximum heart rate and maximum work load determined by fatigue, angina or electrocardiographic evidence of ischemia. The above makes it possible to establish safe training intensities in order to increase the functional physical capacity[3,4,1]. This capacity or physical aptitude is commonly reported using metabolic equivalents (METs) and it has been shown to be a prognostic indicator for event-free survival, all-cause mortality and cardiovascular events[5,6]. Its increase is accompanied by positive influences on the vascular, cardiac, haematological, immunological and nervous systems, it is also considered to be a stronger predictor of mortality when compared to nicotinism, SHBP, high cholesterol, diabetes mellitus and other predictors obtained in an effort test such as segment depression[7].

In view of all the foregoing, the increase in functional physical capacity must be considered to be a fundamental treatment goal for revascularized patients[7]. Furthermore, by recognising factors that exert an influence on functional physical capacity, this could help to improve the coronary disease control strategies following a surgical intervention. Therefore, this study aims to identify the prognostic factors of functional impairment measured through an ergometric test in revascularized patients with acute coronary syndrome.

Material and method

A cross-sectional, descriptive retrospective study was conducted, based on the information derived from the twenty-nine medical histories of patients subjected to an ergometric test after having undergone, for the first time, a revascularization process for acute coronary syndrome (ACS) in the Instituto del Corazón de Bucaramanga (ICB) (Bucaramange Heart Institute) between the months of January and December 2019. The following information was obtained: age, sex, height, weight, ACS type, revascularization type, participation in cardiac rehabilitation programme, number of sessions prescribed, number of sessions completed, cardiovascular risk factors and re-hospitalizations subsequent to revascularization.

Given that the effort tests selected had a diagnostic purpose, the patients suspended the pharmacological treatment to perform them. The only tests selected were those with no electrocardiographic changes compatible with ischemia or rhythm disorders, and in which the reason for the suspension of the tests was fatigue. The variables analysed were: protocol type (Standard Bruce and modified Bruce), baseline HR, maximum HR achieved during the effort test, baseline SAP, maximum SAP achieved during the effort test,baseline SAP, maximum SAP achieved during the effort test, Diastolic Arterial Pressure (DAP), maximum DAP achieved during the effort test, maximum oxygen consumption ($VO_{2máx}$) obtained by indirect measurements, METs, and presence of functional impairment "<7 METs of tolerance to exercise"[8,9].

Statistical analysis

The information obtained was digitised in Excel and the results were analysed through Stata 12.0. The continuous variables were analysed as measures of central tendency and dispersion, the categorical variables through absolute and relative frequencies. In order to estimate the influence of the different factors associated with the functional impairment of the target population of the study, a univariate and multivariate logistic regression was performed (*Odds Ratio*-OR). Additionally, Pearson's test was used to conduct a correlation analysis between tolerance to efforts in METs and the continuous variables of interest. Finally, a simple linear regression analysis was made with those variables showing significant results in the correlation. Associations with $p<0.05$ were considered to be statistically significant.

Ethical considerations

The authors declare that the procedures were conducted in accordance with the ethical standards of the committee responsible for human experimentation and in accordance with the World Medical Association and the Declaration of Helsinki. The study observed the ethical principles of confidentiality, goodwill, non-dysfunction, autonomy and justice. Finally, this investigation was approved by the ethics committee of the Universidad Santo Tomás-Seccional Bucaramanga. (Ethical concept #01402020-1012032020).

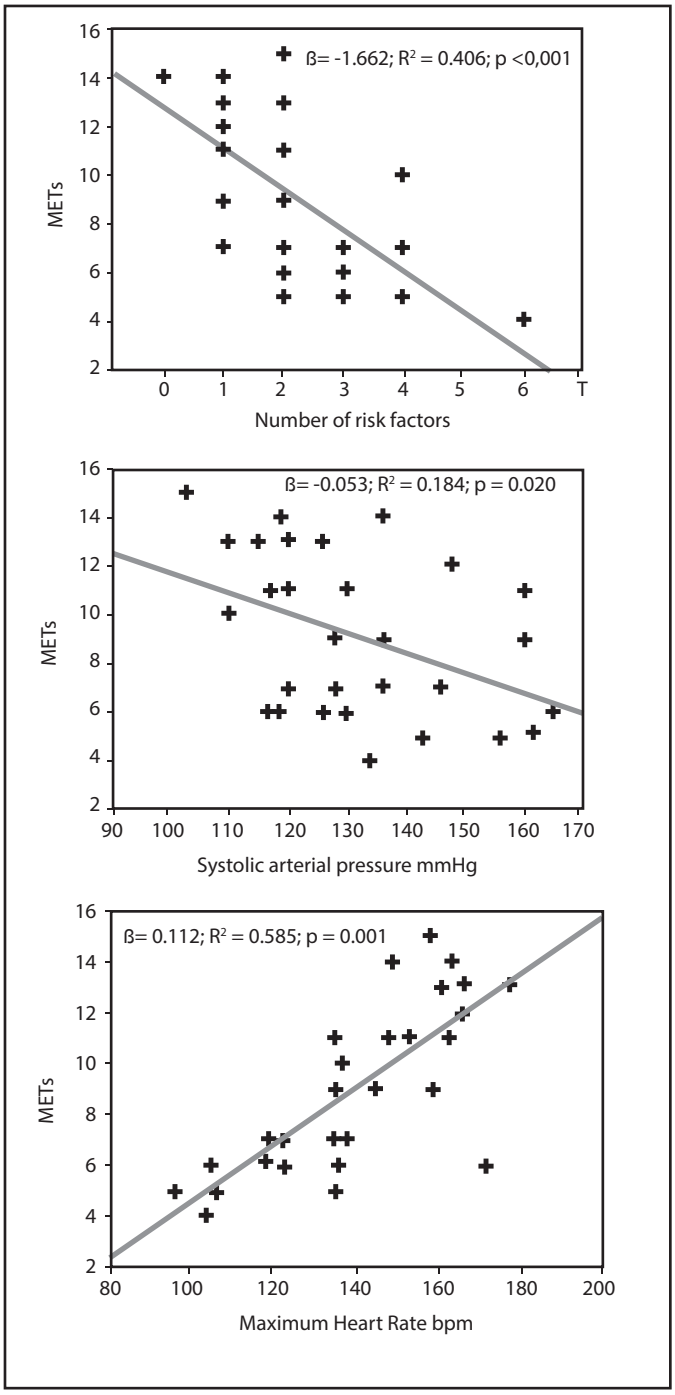
Results

Of the population analysed: the mean age was 60 ± 9.2 years, 76% were men, the most prevalent risk factor was the SHBP present, 83% underwent percutaneous coronary intervention, 86% performed the standard Bruce test and 31% exhibited functional impairment (Table 1).

In the univariate and multivariate analysis, the functional impairment was associated with the presence of hypertension. Hypertension sufferers are 16 times more likely to show functional impairment in comparison with those for whom this diagnosis was not reported (Table 2).

Table 3 shows a direct relationship between tolerance to physical effort and MHR and an indirect relationship between this same variable and the number of risk factors and SAP. According to the linear

Figure 1. Linear regression analysis between functional physical capacity, number of cardiovascular risk factors, SAP and MHR.



regression analysis, an increased MHR value could increase the METs by 0.11 (ß = 0.112; CI: 0.074, 0.149; p <0.001); additionally, for each mmHg increase of SAP, the METs decreased 0.08 (ß = - 0.083; CI 95%: -0.152, -0.014; p <0.020), and for each risk factor unit increase the METs decreased 1.5 (ß = - 1.580; CI 95%: -2.456-0.868; p <0.001) (Figure 1).

Table 1. General characteristics of the population.

Variable		n=29	%
Sex (Male)		22	76
Risk factors			
	Obesity	13	44
	AHT	14	48
	Diabetes	3	10
	Dyslipidemia	10	34
	Nicotinism	3	10
	Ex-nicotinism	12	41
	Family history	1	3
Type of ACS	NSTE-ACS	13	45
	STE-ACS	6	21
	Unstable angina	10	34
Type of percutaneous revascularization		24	83
	Bypass	5	17
Protocol	Bruce Standard	25	86
	Bruce Modified	4	14
Participation in CR		25	86
Functional impairment (<7 METs)		9	31
Rehospitalized		11	38
Variables		**Mean**	**±SD**
	Age (years)	60	9.2
	Height (cm)	166	8.3
	Weight (Kg)	73	10
	BMI (Kg/m²)	26	3
Rehabilitation sessions	Prescribed	21	20
	Completed	16	12
Heart rate	Baseline	67	7,3
	Maximum	141	23
	%Maximum HR	86	12
Blood pressure	SAP	132	17
	DAP	74	10
	Maximum SAP	161	19
	Maximum DAP	84	12
Physical capacity	METs	9	3
	VO_{2max}	32	12

AHT: Arterial hypertension: HR: Heart rate: NSTE-ACS: Non-ST elevation-acute coronary syndrome: STE-ACS: ST elevation acute coronary syndrome: CR: Cardiac rehabilitation; BMI: Body mass index; SAP Systolic arterial pressure: DAP: Diastolic arterial pressure; VO_{2max}: Maximum oxygen consumption.

Discussion

The presence of SHBP, a greater number of risk factors, high levels of maximum SAP and lower maximum HR values achieved during the effort test were shown to be prognostic factors of functional impairment in subjects revascularized for ACS.

The evidence found shows an indirect relationship between functional capacity and arterial pressure levels in hypertensive and normotensive patients[10-14]. Although Tadic M, Ivanovic B. 2014 reported that the mechanisms for the relationship are not entirely clear, they do

Table 2. Factors associated with functional impairment of revascularized patients for ACS.

Variable	OR (95%IC)	p Value	AOR (95% CI)	p Value
Obesity	3.7 (0.704; 19.58)	0.122		
AHT	18 (1.893; 184.0)	0.012	16 (1.010-275.0)	0.049
DM	1.12 (0.088; 14.27)	0.132		
Dyslipidemia	1.86 (0.367; 9.487)	0.452		
Nicotinism	1.12 (0.088; 14.27)	0.928		
Ex-nicotinism	0.10 (0.010; 0.977)	0.048	0.06 (0.003-1.292)	0.704
Participation in CR	0.38 (0.045; 3.323)	0.338		
Rehospitalisation	0.34 (0.057; 2.115)	0.252		

OR: Odds Ratio; AOR: Adjusted Odds Ratio by sex, obesity and diabetes *mellitus*.

Table 3. Correlation between the number of cardiac rehabilitation sessions, effort tolerance level and variables of interest.

Variable	METs r	p
Age -	- 0.24	0.198
BMI	- 0.36	0.050
Number of risk factors	- 0.63	0.002
BHR	0.03	0.873
Maximum HR	0.76	<0.001
SAP	- 0.42	0.020
DAP	- 0.01	0.878
Maximum SAP	- 0.32	0.089
Maximum DAP	- 0.34	0.237

NCRS: number of cardiac rehab sessions; BMI: Body Mass Index: BHR: Baseline Heart rate: SAP: Systolic arterial pressure: DAP: Diastolic arterial pressure; * p <0,05 Spearman test.

point to some possible reasons such as the presence of endothelial dysfunction, mitochondrial and oxidative stress, which could lead to important alterations in the oxygen delivery and uptake rates in the tissues, thereby affecting functional capacity[15-18]. There are other factors that could reduce the level of tolerance to effort in this population, such as an increase in the left ventricle filling pressure, which contributes to the dysfunction and dilatation of the left auricle, thereby deteriorating the diastolic phase of the left ventricle, reducing the cardiac output during physical effort[16,19,20].

The prognostic value shown by the maximum HR could be justified, taking into account the fact that this determines approximately 30% of the maximum cardiac output, thereby influencing the kinetics of oxygen consumption, a variable that defines the functional physical capacity[21]. Moreover, it is known that in apparently healthy subjects, VO_2 increases 7.7 times during maximum intensity exercise. This is achieved thanks to an increase of: 2.5 times the HR, 2.5 times the arteriovenous oxygen difference and 1.4 times the systolic volume, the above being one of the reasons why the HR is considered to be one of the factors that most helps to maintain the functional physical capacity[22,23].

The increase in the maximum HR is primarily conditioned by the expression and functional activity of the adrenergic receptors and by the efficiency of the excitation-contraction coupling. Although these factors are commonly attenuated by ageing and by the extent of the lesion caused by coronary disease, this progressive reduction or alteration of the response of the heart to adrenergic stimulation, does not appear to be so significant in those in better physical condition[21,24-26].

There are other factors that are characteristic of coronary disease and some that are considered to be adverse effects of the anaesthesia or revascualrization surgery, such as the dilatation of the left ventricle and damage to the sinoatrial node that could affect chronotropic performance and the cardiovascular autonomic functions[27,28]. Although the maximum HR is fundamental for the adaptation of the cardiac output to metabolic needs, its role as a biomarker or possible modifiable independent risk factor, as well as its clinical or therapeutic objective in revascularized patients is not clear. For this reason, some studies emphasise the importance of analysing its behaviour, which could strongly predict the evolution of patients of this type[27,21].

The physical functional capacity is considered to be a prognostic factor of the burden of disease for patients with coronary disease. Specifically, the high levels of this capacity are associated with the mitigation of the risk factors, new coronary events, all-cause mortality and cardiovascular events[4,5,29-32]. The above is in keeping with what has been shown in this study, in which the number of cardiovascular risk factors, and the presence of SHBP in particular, were considered to be predictors of functional limitation in subjects subjected to an effort test after having undergone, for the first time, a revascularization process for acute coronary syndrome (ACS). The literature available suggests including cardiorespiratory capacity as part of the risk stratification processes, in patients with cardiovascular disease, which would substantially improve the accuracy of this process[7]; this is taking into account the fact that this variable has been shown to be a stronger predictor when compared to traditional risk factors or those obtained in the effort test such as the depression of the ST segment, the haemodynamic symptoms and responses[7,33,34].

The limitations found include: the nature of the study, that does not make it possible to control the result of the evaluations, thereby

depending on the record reported in the medical histories; the size of the sample that may have been insufficient to detect any other significant associations; the obtaining of the physical capacity by indirect methods, which could be lacking in accuracy, considering that predictive models are more susceptible to confusion factors. Furthermore, it is possible that the results analysed are influenced by the ceiling effect, present when the HR is used as a determining factor of the effort test termination, and by the learning effect, when the patient does not have the possibility to become familiar with the use of the treadmill before starting the test[35].

Conclusions

Our work reinforces the importance of adequate handling of co-morbidities and SHBP in particular, in order to improve the functional capacity of these individuals. The increase in the maximum HR and the attenuation of the SAP are determining factors in the increased tolerance to physical effort in revascularized patients.

The effort tests analysed had a diagnostic objective and, for this reason, it is suggested that they also be used as a patient risk stratification tool based not only on the use of the METs achieved but also on the performance of haemodynamic variables that are simple and relatively easy to obtain such as the maximum HR and the SAP, which were shown to be related to tolerance to physical exercise. They could also show prognostic values for other important conditions to be taken into account during the post-surgery period such as event-free survival levels, all-cause mortality and cardiovascular events in revascularized patients for ACS.

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Conflict of interest

The authors do not declare a conflict of interest.

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