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ORIGINAL STUDY

The relation between heart rate response during exercise and angiographic severity in patients with chronic coronary syndrome

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Abstract

Introduction: **Ellestad and colleagues, in 1975, reached to the conclusion that impaired heart rate response to exercise carries a similar risk for future coronary events such as ischemic 'ST' segment changes.**

Mc Neer and colleagues went beyond these observations to include a survival benefit in patients who achieve a higher peak heart rate (PHR), a more advanced level of exercise, and have a normal exercise electrocardiogram.

Aim: **The aim of this work is to clarify the relation between the chronotropic response to exercise and the severity of coronary artery disease in patients with chronic coronary syndrome.**

Patients and methods: **The study was carried out in the National Heart Institute during the period from May 2019 to March 2020 on 44 patients with clinical suspicion or ECG evidence of chronic coronary syndrome in addition to 10 normal participants as a control group.**

All patients and control persons were subjected to

(1) Full history taking, including personal history, past history, and family history, as well as history of hypertension, diabetes mellitus, and dyslipidemia.

(2) Complete general and local cardiac examination.

(3) Resting 12-lead ECG.

(4) Exercise stress test.

Determination of chronotropic response during exercise test:

(1) PHR.

(2) It is the maximal heart rate achieved during exercise.

(3) The percent maximal age-predicted heart rate (PCT):

PCT=PHR/(220−age in years) × 100

The chronotropic index (CI):

CI=(% HRR)$_2$/(% MR)$_2$

where

(HRR)$_2$ = Heart rate reserve at the end of the second stage.

(MR)$_2$ = Metabolic reserve at the end of the second stage where

% HRR stage = {(HR stage−HR rest)/(maximum age-predicted HR−HR rest)} × 100% MR stage = {(METs stage−METs rest)/(METs peak−METs rest)} × 100.

(4) Patients with positive exercise test were subjected to coronary angiography.

Keywords: CI, PCT, PHR

1. Introduction

Ellestad et al. [1], in 1975, noted that impaired heart rate response to exercise carries the same risk for future coronary events such as ischemic 'ST' segment changes.

Mc Neer et al. [2] extended these observations to include a survival benefit in patients who achieve a

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higher peak heart rate (PHR), a more advanced level of exercise, and have a normal exercise electrocardiogram.

2. Aim of the work

The aim of this work was to clarify the relation between the heart rate response to exercise and the severity of coronary artery disease in patients with chronic coronary syndrome.

3. Patients and methods

The institutional committee's ethical criteria were followed during all proceedings. The National Heart institute's Local Medical Ethics Committee approved the study. Following an explanation of the purpose, procedures, and nature of the study to all participants, signed informed consent was obtained from each participant.

The study was carried out in the National Heart Institute during the period from May 2019 to March 2020 on 44 patients with clinical suspicion or ECG evidence of chronic coronary syndrome in addition to 10 normal participants as a control group.

All patients and control persons were subjected to

(1) Full history taking, including personal history, past history, and family history, as well as history of hypertension, diabetes mellitus, and dyslipidemia.
(2) Complete general and local cardiac examination.
(3) Resting twelve-lead ECG.
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Determination of chronotropic response during exercise test

(1) PHR:

It is the maximal heart rate achieved during exercise.

(2) The percent maximal age-predicted heart rate (PCT):

PCT= PHR/(220−age in years) × 100

(3) The chronotropic index (CI):

$CI=(\% \ HRR)_2/(\% \ MR)_2$ where

$(HRR)_2$ = heart rate reserve at the end of the second stage.

$(MR)_2$ = metabolic reserve at the end of the second stage where.

% HRR stage = {(HR stage−HR rest)/(maximum age-predicted HR−HR rest)} × 100% MR stage = {(METs stage−METs rest)/(METs peak−METs rest)} × 100.

Table 1. Comparison of demographic data and risk factors in patients and control group.

Parameter	Control group		Patients	
	Frequency	Percentage	Frequency	Percentage
Sex				
Male	4	40	35	79.5
Female	6	60	9	20.5
Smoking				
Yes	4	40	30	68.2
No	6	60	14	31.8
Diabetes				
Yes	0	0	25	56.8
No	10	100	19	43.2
Hypertension				
Yes	3	30	21	47.7
No	7	70	23	52.3
Dyslipidemia				
Yes	0	0	25	56.8
No	10	100	19	43.2
Obesity				
Yes	6	60	10	22.7
No	4	40	34	77.3
Previous MI				
Yes	0	0	8	18.2
No	10	100	36	81.8

MI, myocardial infarction.

(4) Patients with positive exercise test were subjected to coronary angiography.

4. Results

In this study, 44 patients were included (35 males and nine females) with an age range from 32 to 69 years in addition to 10 normal participants taken as a control group (four males and six females) with an age range from 45 to 71 years (Tables 1–4, Fig. 1).

4.1. Sensitivity and specificity of the chronotropic parameters

From the previous tables and figures, we can estimate the sensitivity and specificity of each parameter

Table 2. Comparison in the exercise test findings between the patients and control group.

Parameter	Control group		Patients	
	Frequency	Percentage	Frequency	Percentage
Blood pressure response				
Normal	7	70	24	54.5
Hypertensive	3	30	20	45.5
Test result				
Positive	0	0	35	79
Negative	10	100	5	12
Inconclusive	0	0	4	9
Chronotropic parameters	Mean ± SD	Mean ± SD	*P* value	Significance
PHR	165.5 ± 5.32	135.2 ± 14.51	<0.01	HS
%HR	97.70 ± 3.43	77.84 ± 8.24	<0.01	HS
CI	1.05 ± 0.10	0.51 ± 0.20	<0.01	HS

CI, chronotropic index; HR, heart rate; PHR, peak heart rate.

Table 3. Comparison in the angiographic findings between patients and control group.

	Control group		Patients	
Parameter	Frequency	Percentage	Frequency	Percentage
Normal	10	100	0	0
Single-vessel disease	0	0	9	20.5
Two-vessel disease without proximal LAD	0	0	8	18.2
Two-vessel disease including proximal LAD	0	0	14	31.8
Three-vessel disease or more	0	0	9	20.5
Left main disease	0	0	4	9.1

LAD, left anterior descending.

Table 4. The relation between exercise test and angiographic findings in patients and control group.

Angiographic findings	Peak heart rate (PHR)	% Target heart rate (%THR)	Chronotropic index (CI)
Normal coronary angiography	159–175	94–100	0.96–1.23
Single-vessel disease	138–156	81–90	0.78–0.90
Two-vessel disease without proximal LAD	125–155	71–87	0.61–0.73
Two-vessels disease, including proximal LAD	115–152	63–85	0.42–0.54
Three-vessel disease or more	114–129	67–76	0.32–0.41
Left main disease	95–120	59–69	0.13–0.026

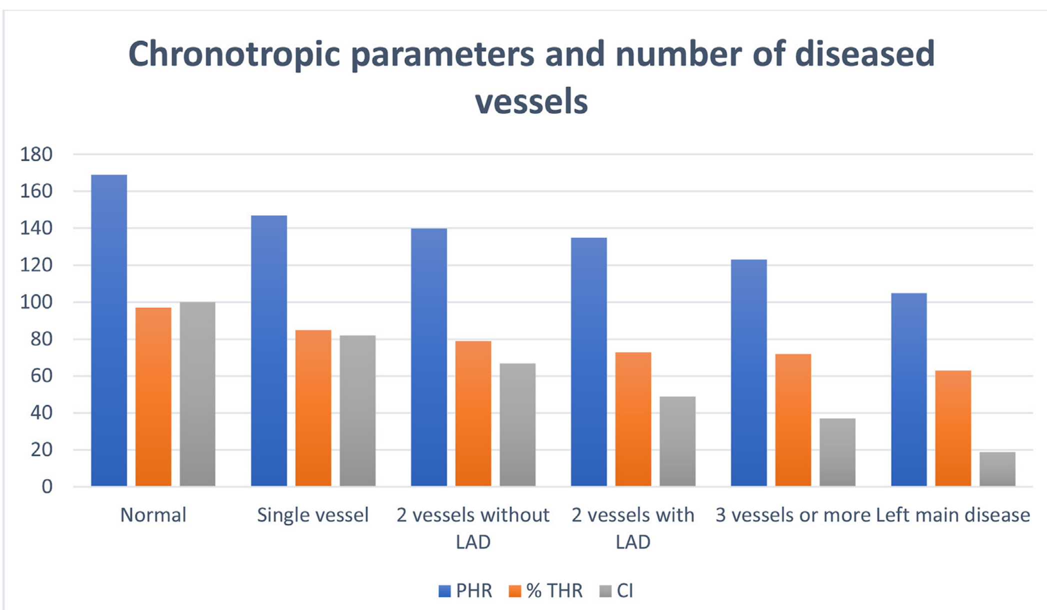

Fig. 1. The relation between the chronotropic parameters and the number of diseased vessels.

to detect the severity of the coronary artery disease and to detect the mere presence of the disease.

4.2. PHR

As a whole, the sensitivity of PHR as a parameter to detect those with coronary artery disease from normal participants is 84.4%, while its specificity is 40.0%.

4.3. Percentage of target heart rate (%THR)

As a whole, the sensitivity of the %THR as a parameter to detect those with coronary artery disease from normal participants is 96%, while its specificity is 59.6%.

4.4. CI

As a whole, the sensitivity of the CI as a parameter to detect those with coronary artery disease from normal participants is 100%, while its specificity is 96%.

5. Discussion

Many previous investigators tried to study the importance of chronotropic response during exercise stress testing and correlating it with the severity of coronary artery disease as well as the cardiovascular outcome.

In our study, we found that severe coronary artery disease is associated with a lower PHR, lower % THR, and a lower CI.

In agreement with our study, Lauer et al. [3] stated that chronotropic incompetence in the form of low CI is a marker of adverse cardiovascular prognosis.

Similarly, Francis et al. [4], stated that among patients with coronary artery disease, impaired heart rate response during exercise can independently predict all-cause mortality.

The same idea was the aim of a study done by Joselina et al. [5], when they studied the chronotropic response of the patients during exercise echocardiography and reached to the conclusion that chronotropic incompetence is associated with an extensive myocardial ischemia during exercise echocardiography.

All previous studies tried to prove the importance of chronotropic incompetence as a valuable predictor of the severity of coronary artery disease without actual correlation with the patients' coronary angiogram.

Chin and colleagues were the first to correlate the chronotropic response with the coronary angiogram but without establishing solid rules to predict such angiographic picture from the chronotropic response.

They studied a number of patients that showed chronotropic incompetence during exercise without 'ST' shift and compared such results with their coronary angiogram. They reached to the conclusion that more than 70% of such patients had significant coronary artery disease [6].

In our study, we tried to clarify more the relation between the heart rate response during exercise and the severity of coronary artery disease as judged by the angiographic picture in the form of the number of vessels involved, so that by the use of these chronotropic parameters, we can predict the severity of coronary involvement.

In our study, we established solid rules and fixed figures from which the number of coronary vessels involved – thus reflecting the size of jeopardized myocardium – as well as the plan of management can be determined before invasive coronary angiography is done.

5.1. Conclusion

Chronotropic response during exercise is an important and reliable variable for the prediction of coronary artery disease severity.

All the three chronotropic parameters, the PHR, the %THR, and the CI are of high predictive value as regards the severity of coronary involvement, but the CI still remains the one of highest sensitivity.

These results cannot be explained by the just involvement of the SAN branch of the right coronary artery, but related to the size of the jeopardized myocardium.

Conflict of interest

None declared.

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