JACC: HEART FAILURE
VOL. 3, NO. 10, 2015
© 2015 BY THE AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION
ISSN 2213-1779/$36.00
PUBLISHED BY ELSEVIER INC.
http://dx.doi.org/10.1016/j.jchf.2015.05.010

CLINICAL RESEARCH

Determinants of Effort Intolerance in Patients With Heart Failure

Combined Echocardiography and Cardiopulmonary Stress Protocol

Jason Shimiaie, MD,* Jack Sherez, BSc,* Galit Aviram, MD,† Ricki Megidish, BSc,* Sami Viskin, MD,* Amir Halkin, MD,* Meirav Ingbir, MD,* Nahum Nesher, MD,‡ Simon Biner, MD,* Gad Keren, MD,* Yan Topilsky, MD*

ABSTRACT

OBJECTIVES The purpose of this study was to assess individual mechanisms of effort intolerance in patients with heart failure with preserved ejection fraction (HFpEF), heart failure with reduced ejection fraction (HFrEF), or normal cardiac function using combined echocardiography and cardiopulmonary stress testing.

BACKGROUND Combined stress echocardiography and cardiopulmonary tests visualize cardiac chambers in 4 well-defined activity levels (rest, unloaded, anaerobic threshold, and peak), allowing noninvasive assessment of cardiac function, hemodynamics, and arterial venous oxygen content difference (AVo_2Diff) during all stages.

METHODS Left ventricular volumes, stroke volume (SV), S', E/e', oxygen consumption (Vo_2), and AVo_2Diff were measured in all effort stages using ramp semirecumbent cycle prolonged (≥8 min) exercise in 45 consecutive subjects evaluated for effort intolerance (14 normal cardiac function, 16 HFpEF, and 15 HFrEF patients; age 56.5 ± 16 years; 73% male).

RESULTS In HFpEF and HFrEF, the changes in Vo_2 were attenuated (between group $p = 0.003$; group by time interaction $p < 0.0001$), as well as peak heart rate ($p = 0.0001$; $p = 0.0001$) and SV ($p = 0.006$; $p = 0.0001$). End-diastolic volume to E/e' ratio (measure of compliance) was superior in HFrEF and normal patients at baseline but worsened in HFpEF and HFrEF at peak exercise (8.3 ± 4 vs. 11.6 ± 5 vs. 19.1 ± 8; $p = 0.004$; $p = 0.01$). Functional mitral regurgitation worsened even during the unloaded stage, mostly in patients with HFrEF, but also in several patients with HFpEF. In multivariable analysis, heart rate response ($p = 0.007$), and AVo_2Diff ($p < 0.0001$) were the most significant independent predictors of effort capacity; SV was not.

CONCLUSIONS Combined tests are feasible and allow noninvasive evaluation of effort intolerance. In HFpEF and HFrEF patients, exercise intolerance is predominantly due to chronotropic incompetence and peripheral factors. Combined stress echocardiography and cardiopulmonary tests may have potential for clinical management and selection of patients for trials. (J Am Coll Cardiol HF 2015;3:803–14) © 2015 by the American College of Cardiology Foundation.

Multiple mechanisms are held responsible for the limited exercise capacity of patients with heart failure (HF) with preserved (HFpEF) or reduced (HFrEF) left ventricular (LV) ejection fraction (EF) (1-8). Studies of exercise limitation in HF have predominantly used standard exercise tests or radionuclide ventriculography combined with invasive hemodynamic assessment.

From the *Division of Cardiovascular Diseases and Internal Medicine, Tel Aviv Medical Center, Tel Aviv, Israel; †Division of Radiology, Tel Aviv Medical Center, Tel Aviv, Israel; and the ‡Division of Cardiovascular Surgery, Tel Aviv Medical Center, Tel Aviv, Israel. The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Manuscript received April 1, 2015; revised manuscript received May 19, 2015, accepted May 26, 2015.

JACC: HEART FAILURE VOL. 3, NO. 10, 2015
OCTOBER 2015:803–14

ABBREVIATIONS AND ACRONYMS

AVO_2Diff = arterial venous oxygen content difference

CPET = cardiopulmonary exercise test

EF = ejection fraction

FEV_1 = forced expiratory volume first second

HF = heart failure

HFpEF = heart failure with preserved ejection fraction

HFrEF = heart failure with reduced ejection fraction

LV = left ventricle

LVEDV = left ventricular end-diastolic volume

MR = mitral regurgitation

SE = stress echocardiography

SV = stroke volume

V_{CO_2} = carbon dioxide production

V_{O_2} = oxygen consumption

They have been limited by their invasive nature, resulting in selection bias, and by the insufficient anatomic data provided with ventriculography (1,5). Several studies have used stress echocardiography (SE) to assess factors limiting maximal exercise capacity by comparing rest to peak exercise (2,9,10).

SEE PAGE 815

Because HF patients rarely exercise at maximal intensities, and submaximal exercise capacity is more applicable to everyday life, it is particularly important to expand the understanding of cardiac peripheral and vascular responses to submaximal exercise in this population. Cardiopulmonary exercise tests (CPET) are able to recognize and divide effort into 4 activity levels (rest, unloaded cycling, anaerobic threshold, and peak), allowing assessment of cardiac function during all exercise levels. Therefore, we have created a new combined cardiopulmonary stress test and SE protocol enabling the noninvasive assessment of multiple cardiac and peripheral responses to dynamic exercise, in all 4 predefined activity levels.

METHODS

STUDY POPULATION. Between January 1, 2013 and September 30, 2013, we performed 72 combined CPET and SE examinations using our new protocol. All patients were clinically stable and ambulatory, and referred for evaluation of effort intolerance or dyspnea. Patients presenting with primary valvular disease (aortic valve replacement, n = 2; aortic stenosis, n = 2; rheumatic mitral stenosis, n = 4; organic mitral regurgitation [MR], n = 1), hypertrophic cardiomyopathy (n = 6), sinoatrial block (n = 1), active ischemia (n = 2), atrial septal defect (n = 1), primary pulmonary hypertension (n = 1), mitochondrial myopathy (n = 1), unable to complete exercise on semirecumbent bicycle (respiratory exchange ratio <1.0; n = 4), or with inadequate acoustic windows (n = 2) were excluded from the study. The remaining patients were divided into 3 groups (controls, HFpEF, and HFrEF). Control patients were clinical patients referred to the test for dyspnea of unknown origin. Eight patients were concluded to have effort dyspnea related to peripheral factors based on normal LV, right ventricle systolic and diastolic function, and impaired oxygen extraction in peripheral muscles. The remaining 7 patients had normal exercise capacity. Diagnosis of HFpEF and HFrEF was made clinically before the test based on clinical signs and symptoms of HF as defined by the criteria of Rich et al. (11). Patients were defined to have HFpEF when they had a normal resting EF (≥50%), or HFrEF when they had a low resting EF (<50%) (Table 1).

EXERCISE PROTOCOL. A symptom-limited graded ramp bicycle exercise test was performed in the semisupine position on a tilting, dedicated, microprocessor-controlled eddy current brake stress echocardiography cycle ergo meter (Ergoselect 1000 L, CareFusion, San Diego, California). We estimated the expected peak oxygen consumption (V_{O_2}) based on patient age, height, and weight after considering the patient's history. We then calculated the work rate increment necessary to reach the patient's estimated peak V_{O_2} in 8 to 12 min. The protocol included 3 min of unloaded pedaling, a symptom-limited ramp-graded exercise, and 2 min of recovery. Breath-by-breath minute ventilation, carbon dioxide production (V_{CO_2}), and oxygen consumption (V_{O_2}) were measured using a Medical Graphics metabolic cart (ZAN, nSpire Health Inc., Longmont, Colorado). Peak V_{O_2} was the highest averaged 30-s V_{O_2} during exercise (12). Ventilation/V_{CO_2} was defined as the lowest immediately after anaerobic threshold, and was expressed as absolute nadir ventilation/V_{CO_2} (12,13). Anaerobic threshold was determined manually using the modified V-slope method (13). A 12-lead electrocardiograph and noninvasive arterial saturation were monitored continuously; heart rate and blood pressure were measured at rest and every minute during exercise. β-Blockers and calcium blockers were left unchanged. The metabolic-chronotropic relationship was calculated from the ratio of the HR reserve to the metabolic reserve during submaximal exercise. A metabolic-chronotropic relationship slope of <0.80 was considered indicative of chronotropic incompetence (14,15). In patients on β-blocker or calcium blocker therapy, chronotropic incompetence was defined whenever <62% of heart rate reserve was used (16).

EXERCISE ECHOCARDIOGRAPHY TESTING. Echocardiographic images were obtained concurrently with breath-by-breath gas exchange measurements, at rest, during the 3-min period of unloaded exercise, immediately after reaching the anaerobic threshold, and at maximal exercise capacity, defined as immediately after reaching a respiratory exchange ratio of >1.05. Data collected at each time period included left ventricular end-diastolic volume (LVEDV), end-systolic volume, EF, stroke volume (SV), peak E-wave and A-wave velocities, E-wave

Download English Version:

https://daneshyari.com/en/article/2942373

Download Persian Version:

https://daneshyari.com/article/2942373

Daneshyari.com