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Monitoring functional capacity in heart failure

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This document reflects the key points of a consensus meeting of the Heart Failure Association of European Society of Cardiology (ESC) held to provide an overview the role of physiological monitoring in the complex multimorbid heart failure (HF) patient. This article reviews assessments of the functional ability of patients with HF. The gold standard measurement of cardiovascular functional capacity is peak oxygen consumption obtained from a cardiopulmonary exercise test. The 6-min walk test provides an indirect measure of cardiovascular functional capacity. Muscular functional capacity is assessed using either a 1–repetition maximum test of the upper and lower body or other methods, such as handgrip measurement. The short physical performance battery may provide a helpful, indirect indication of muscular functional capacity.

Introduction

One of the hallmark features of heart failure (HF) is exercise intolerance, which is accompanied by symptoms of fatigue and shortness of breath.[1,2] As the disease progresses, patients experience a downward spiral as these symptoms typically result in reduced physical activity, which leads to progressively worsening exercise intolerance.[3,4] Typically, patients with HF are faced with what can be termed a functional disability.[5-7] Often, their reduced functional abilities restrict or may even prevent them from performing occupational tasks, which may result in loss of work.[8] Additionally, it is well known that HF patients experience impairment in the ability to carry out activities of daily living and suffer from an impaired quality of life.[9-11]

Cardiopulmonary exercise testing

The gold standard method for assessing cardiovascular functional capacity is measurement of oxygen consumption (VO2) during a maximal exercise test.[12-14] This procedure is known as cardiopulmonary exercise testing (CPET).[15-17] The principal outcome variable is maximal or peak oxygen VO2 ($VO2_{max}$ or $VO2_{peak}$). Historically, VO2max is used when the measurement methodology includes determination of a plateau in VO2 measurement values during the last work rate. In clinical practice of HF, the $VO2_{peak}$ is measured as the highest VO2 value, expressed as millilitres of oxygen per kilogram of body weight per minute (mLO2 $kg^{-1} min^{-1}$) during the exercise test.[18] Recent reports from the Heart Failure Association of the European Society of Cardiology (ESC)[19] provides a stratification approach for diagnosis and prognosis of patients with HF.[20] The key CPET measurements, all clearly defined in the report, included in the stratification are the slope of minute ventilation (VE) relative to carbon dioxide production (VCO2; VE/VCO2 slope); peak VO2; exercise oscillatory ventilation; and the change in the partial pressure of carbon.[21-24] The stratification also includes consideration of the blood pressure and electrocardiographic response during the exercise test.[25-27]

Today CPET is used in broader patient populations, including women, the elderly, patients with comorbidities, those with preserved ejection fraction, or left ventricular assistance device recipients, i.e. individuals with different responses to incremental exercise and markedly different prognosis.[28-30] In addition, the diagnostic and prognostic utility of symptom-limited CPET parameters derived from submaximal tests has been studied more and more recently, for the reason that many patients are unable to

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achieve maximal aerobic power.[31-33] Repeated tests are also being used for risk stratification and evaluation of interventions, so that more evaluative data are now available. Finally, patients, physicians, and healthcare decision makers are increasingly considering how treatments might impact morbidity and quality of life rather than focusing more exclusively on hard endpoints (such as mortality) as was often the case in the past. Innovative prognostic flowcharts, with CPET at their core, that help optimize risk stratification and the selection of management options in HF patients, have been developed.[34]

Six-minute walk test

The role of the walking test for 6 min in providing useful information in patient populations with functional limitations was proposed decades ago.[35] Since that time, the 6-min walk test (6MWT) has gained acceptance in the clinical community as a feasible option to obtain an estimate of cardiovascular functional capacity in disease-based populations known to experience exercise intolerance.[36]

The 6MWT is considered simple in concept in terms of the patient directions. The ATS guidelines provide recommendations for standardizing the communication with the patient during the test.[37] However, it is important to recognize that the 6MWT does not accurately predict peak VO2. Some reports have suggested that failure to achieve a certain distance, such as 300 m or 450 m, on the 6MWT has prognostic value. Additionally, some have proposed that measures other than total distance achieved, such as total work performed or heart rate after 1 min of recovery may provide useful information from the 6MWT. However, there are no well-accepted normative values available to interpret 6MWT results.[38]

The shuttle walk test (SWT) has been also proposed to evaluate chronic disease patient populations.[39] This test requires patients to walk back and forth around two markers on a 10-m course (each 10 m = 1 shuttle) at a pace dictated by audio signals recorded on a cassette tape or CD. The speed is initially set at 0.5 m/s and increased by 0.17 m/s every minute. The test is terminated when the patient cannot complete a shuttle in the required time interval. As with the 6MWT, it is recommended that only standardized comments (no encouragement) be provided and that the SWT is repeated at least twice to account for a learning effect.

Other walking tests have been proposed, i.e. a 100-m walk test in patients with pulmonary disease, 200-m fast walking in patients in cardiac rehabilitation, and a 400-m walk test in patients with HF: however their prognostic powers still need to be documented.[40]

Table 1 summarizes the key differences between CPET vs. 6MWT.

Table 1 Comparative features of CPET and 6MWT

	6-min walk test	CPET
Exercise level	Submaximal	Maximal
Reproducibility	+	+++
Availability/cost	+++	+
Patient acceptance	+++	+
Clinical results	+	+++
Prognostic value	++	+++
Patient application	Older/frail	Transplant/VAD list

Muscular function

One of the most frequent misconceptions of HF is that the limitations are solely related to the heart.[14,41,42] Evidence has existed for some time that one of significant factors associated with exercise intolerance in patients with HF is skeletal muscle deconditioning.[43,44] Recent studies have identified mechanisms underlying the weakness observed in the skeletal muscles or patients with HF.[45,46]

Thus, is it now well accepted that functional assessments of patients with HF should include measures of muscular performance.[47] The gold standard method to assess muscular strength is the 1–repetition maximum test (1–RM). The resistance for the lifting can be either free weights or resistance exercise machines.

Although a 1–RM can be obtained from any weight lifting exercise, the two most common lifts are the bench press (for upper body strength) and the leg press (for lower body strength). Unfortunately, there are no definitive standards for interpreting 1–RM performance in patients with HF. One of the major issues with performing 1–RM assessments is the time requirement, especially if patients need to be familiarized with using the free weights or machines.

A second option for performing muscular function assessments is to use a handgrip dynamometer. The procedure is simple, only requiring the patient to squeeze the handle of the dynamometer as hard as they can for 3 s. After a short rest, the test is repeated two more times, with each hand being tested. Although normative values specific for patients with HF do not exist, large population standards are available. These tests are starting to be administered in the HF population.[48]

There are also indirect measures of muscular strength that can be used as indicators of muscular functional ability.[49-51] The origins for many of these evaluations came from work with geriatric populations. The method that seems to be gaining the most acceptance is the Short Physical Performance Battery (SPPB).[52]

Questionnaires

Questionnaires have been proposed.[53,54] Myers *et al.* evaluated the Duke Activity Status Index, the Kansas City Cardiomyopathy Questionnaire, and the Veterans Specific Activity Questionnaire, with results from CPET and the 6MWT: these different methods did not correlate well with each other and concluded that they should not be used as surrogate indicators of functional status in this population.[55,56]

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