

## Cardiopulmonary Exercise Testing in Patients With Heart Failure

A recent issue of the *Journal* included two articles (1,2) involving cardiopulmonary exercise testing in patients with heart failure. Despite the clinical consequences of this test, there is no standardization of the compilation of results from the raw data. Interestingly, there is a great deal of literature involving the determination of ventilatory threshold but little standardization within or between medical centers regarding the determination of the peak oxygen consumption ( $\text{VO}_2$ ) value.

In the de Groote et al. article (1), there are two primary omissions concerning the cardiopulmonary exercise test. First, the peak  $\text{VE}/\text{VCO}_2$  slope is not presented despite evidence that it is the best individual predictor of mortality obtained from the cardiopulmonary exercise test in this patient population (3). In combination with peak  $\text{VO}_2$ , peak  $\text{VE}/\text{VCO}_2$  slope provides additional prognostic information (3,4). Second, the peak respiratory exchange ratio must always be reported alongside the peak  $\text{VO}_2$ . Peak respiratory exchange ratio is valuable because it permits an evaluation of the cardiopulmonary limitation to exercise but also provides prognostic information because exercise tests that are considered to be maximal have greater prognostic ability than those that are submaximal (5–7).

Because ventilatory efficiency is a powerful mortality predictor and the evaluation of cardiopulmonary exercise tests have dramatic consequences, authors, editors, and clinicians must take great care to standardize the evaluation and reporting of cardiopulmonary exercise testing data in patients with heart failure.

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## REPLY

We would like to thank the author for his comments regarding our paper (1) and the use of cardiopulmonary exercise testing and in particular the importance of the peak respiratory exchange ratio, which was used in our recently published article. We do agree that cardiopulmonary exercise testing needs to be standardized in cardiac patients, particularly those with heart failure because of their important and powerful predicting value.

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## REPLY

The letter by Dr. Bard raises the important aspect of the standardization of the cardiopulmonary exercise test (CPT). We agree that peak respiratory exchange ratio (RER) is a mandatory parameter for the interpretation of CPT. Peak RER is a good index of a maximal effort, and prognostic value of peak  $\text{VO}_2$  is dependent on peak RER (1). As in our previous studies (2,3), peak RER in the present study (4) was elevated ( $1.17 \pm 0.14$ ), with a significant difference between survivors and nonsurvivors ( $1.18 \pm 0.14$  vs.  $1.14 \pm 0.13$ ;  $p = 0.03$ ). However, peak RER was not an independent predictor of cardiac survival.

We also agree that the analysis of the ventilatory efficiency of the patients, determined either by the peak  $\text{VE}/\text{VCO}_2$  or by the  $\text{VE}/\text{VCO}_2$  slope, could bring important prognostic information (5–7). As suggested by Dr. Bard, it is important to standardize the analysis of the results of the CPT. However, the major problem with the  $\text{VE}/\text{VCO}_2$  slope is the nonstandardization of its determination. In some patients, the relationship between  $\text{VE}$  and  $\text{VCO}_2$  is not linear, and two slopes could be determined, the second one steeper than the first one. Several methods have been used for the determination of the  $\text{VE}/\text{VCO}_2$  slope (using all the data of the exercise or only data obtained before or after the ventilatory threshold). Preliminary results suggest that the best method is to use all the data from the exercise (8,9). Because the determination of the  $\text{VE}/\text{VCO}_2$  slope is not yet standardized, it is difficult to include it in prognostic studies. However, when peak  $\text{VE}/\text{VCO}_2$  was included in our multivariate analysis, it was not an independent predictor of cardiac survival. Currently, peak  $\text{VO}_2$  remains the most powerful prognostic parameter of the CPT in our population.