

Cardiopulmonary Exercise Testing in Heart Failure

This is a summary of the original article cited below. This summary is authored by Edward A. Rose, M.D., Medical Writer and a consultant for Vyair Medical*.

Authors: Rajeev Malhotra, MD^a, Kristian Bakken, NP^b, Emilia D'Elia, MD, PHD^{c,c}, Gregory D. Lewis, MD^{a,b}

Introduction

During cardiopulmonary exercise testing (CPET), maximal $\text{VO}_{2\text{max}}$ is measured, making CPET the "gold standard" measure of maximal functional capacity. During CPET, ventilatory parameters can be measured together with blood pressure, arterial blood gasses, and heart rate (HR), thereby providing insight into mechanisms of functional limitations. Hallmark abnormalities of heart failure (HF) during CPET are decreases in $\text{VO}_{2\text{max}}$, oxygen pulse, and ventilatory efficiency, all reflecting an impaired exercise cardiac output and hampered O_2 delivery. Measuring ventilatory patterns and VO_2 update can help determine disease severity and prognosis.

Peak VO_2

VO_2 measured at maximal symptom-limited exercise during CPET provides the best method to assess functional capacity. [1] Heart rate is multiplied by stroke volume and oxygen extraction by peripheral tissues to result in peak VO_2 . This value must be adjusted according to age, sex, and body weight. When peak VO_2 is below 14 ml/kg/min, the patient is deemed to be a candidate for transplantation.

Submaximal O_2 Uptake Measurements

Recent studies have identified submaximal exercise gas exchange variables that improve upon the predictive ability of CPET. [1-3] Oxygen kinetics, oxygen uptake efficiency slope (OUES), VO_2 at the ventilatory threshold, and a plateau in the oxygen pulse (VO_2/HR) curve provide detailed data on metabolic and cardiac function. The assessment of aerobic efficiency represented by VO_2 per unit of work predicts patient responses to low-level exercise, activities of daily living, and independence, and relates closely to prognosis in heart failure (HF). Estimation of submaximal gas exchange parameters presented as slopes is particularly helpful when patients do not clearly meet criteria for a maximal volitional exertion as determined by a respiratory exchange ratio <1.0 to 1.1. See Figure 1.

* Vyair Medical respiratory diagnostics is now Jaeger Medical.

^a Cardiology Division, Department of Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, MA.

^b Pulmonary and Critical Care Unit of the Department of Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, MA.

^c Cardiovascular Department, Hospital Papa Giovanni XXIII, Bergamo Italy.

^d University of Pavia, Pavia, Italy.

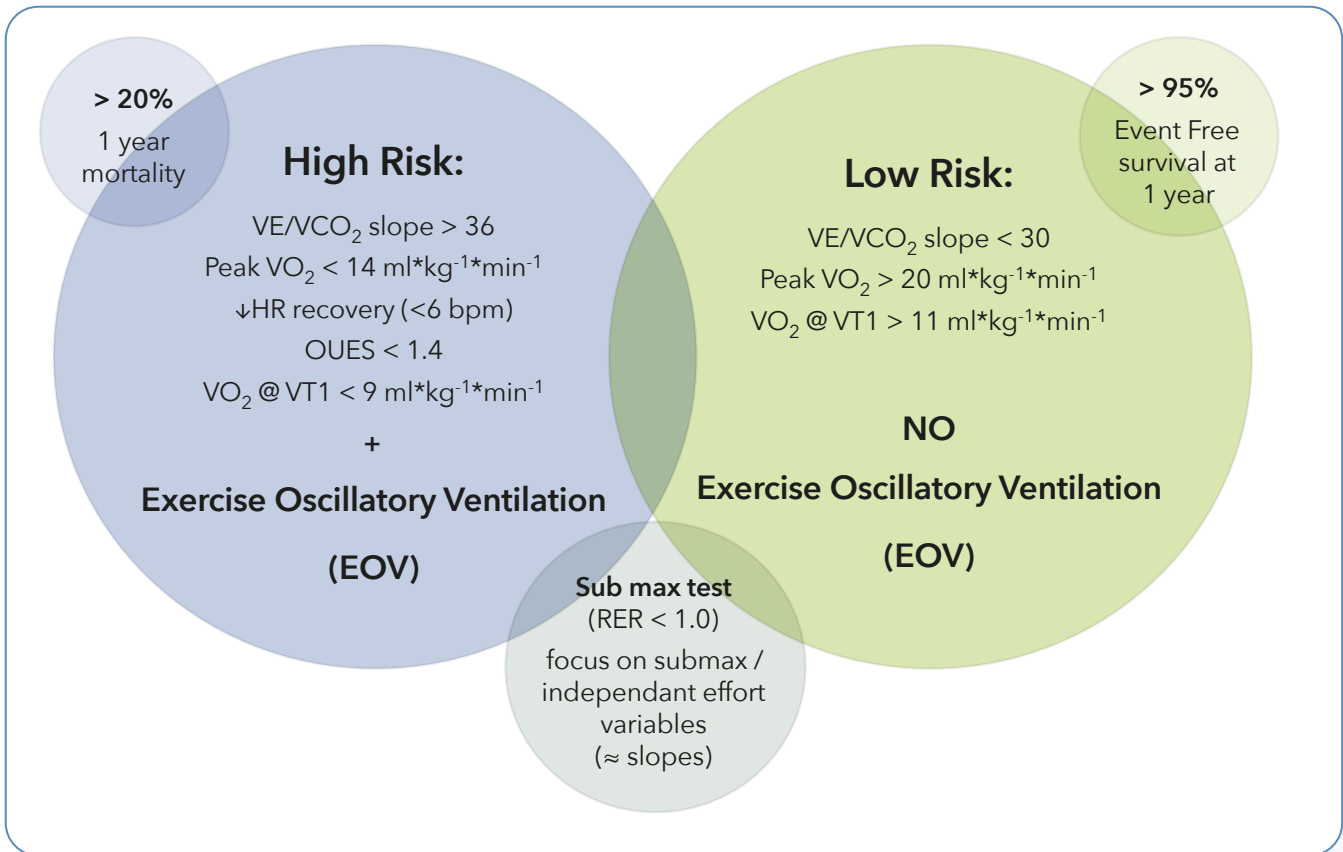


Figure 1. Respiratory exchange ratio (RER).



Figure 2. Vyntus™ CPX is an example of a CPET measuring device*.

Synopsis of Practical Approach to CPET Interpretation in Patients with HF

- VO₂ is the current gold standard of cardiorespiratory fitness and functional capacity. Measurement of VO₂ is therefore critical.
- Identification of volitional effort guides the diagnostic focus on gas exchange parameters that are effort independent (OUES, O₂-pulse, = oxygen pulse response, and VO₂ at the ventilatory threshold).
- Further investigation then involves identifying the failure to augment systolic blood pressure or slow heart rate recovery.
- While ventilatory efficiency and stability help grade the severity of HF, a steep VE/VCO₂ slope and the presence of EOV indicate increased mortality risk.

Ventilatory Efficiency and Stability During Exercise in HF

Reduced efficiency of ventilation is shown by a high VE/VCO₂ slope associated with increased pulmonary vascular resistance and decreased right ventricular ejection fraction. The VE/VCO₂ slope is recognized as a powerful predictor of HF events. Periodic breathing during exercise, reported as exercise oscillatory ventilation (EOV), is seen in many patients with advanced HF and is consistently associated with a 1-year mortality >20%. [4].

*Vyntus™ CPX was not used in this study.

References


1. Balady GJ, Arena R, Sietsema K, Myers J, Coke L, Fletcher GF, et al. Clinician's Guide to cardiopulmonary exercise testing in adults: a scientific statement from the American Heart Association. *Circulation*. 2010;122(2):191-225. <http://dx.doi.org/10.1161/CIR.0b013e3181e52e69>.
2. Corra U, Piepoli MF, Adamopoulos S, Agostoni P, Coats AJ, Conraads V, et al. Cardiopulmonary exercise testing in systolic heart failure in 2014: the evolving prognostic role: a position paper from the committee on exercise physiology and training of the heart failure association of the ESC. *Eur J Heart Fail*. 2014;16(9):929-941. <http://dx.doi.org/10.1002/ejhf.156>.
3. Guazzi M, Adams V, Conraads V, Halle M, Mezzani A, Vanhees L, et al. Clinical recommendations for cardiopulmonary exercise testing data assessment in specific patient populations. *Circulation*. 2012;126(18):2261-2274.
4. Corra U, Pistono M, Mezzani A, Braghiroli A, Giordano A, Lanfranchi P, et al. Sleep and exertional periodic breathing in chronic heart failure: prognostic importance and interdependence. *Circulation*. 2006;113(1):44-50. <http://dx.doi.org/10.1161/CIRCULATIONAHA.105.543173>.

For more details on the content of the study, please refer to the original article here.

Malhotra R, Bakken K, D'Elia E, Lewis GD. Cardiopulmonary Exercise Testing in Heart Failure. *JACC Heart Fail*. 2016 Aug;4(8):607-16. doi: 10.1016/j.jchf.2016.03.022. Epub 2016 Jun 8. PMID: 27289406.

This document is intended for health care professionals for educational purposes only.



 Jaeger Medical GmbH
Leibnizstrasse 7
97204 Hoechberg
Germany

Jaeger Medical America, Inc.
14050 Rebecca St, Bldg 4
Moreno Valley, CA 92553
USA

For global distribution.

© 2025 Jaeger Medical GmbH. Jaeger and the Jaeger logo are trademarks or registered trademarks of Jaeger Medical GmbH or one of its affiliates. Jaeger Medical devices are class I & IIa according to Medical Devices Directive 93/42/EEC or Medical Device Regulation EU 2017/745 as indicated on each declaration of conformity. Please read the complete Instructions For Use that come with the devices or follow the instructions on the product labeling. JAE-GBL-2500045 | 1.0

