

# Exercise End-Tidal CO<sub>2</sub> Predicts Central Sleep Apnea in Patients With Heart Failure

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**BACKGROUND:** Increased CO<sub>2</sub> chemosensitivity and augmented exercise ventilation are characteristic of patients with heart failure (HF) with central sleep apnea (CSA). The aim of this study was to test the hypothesis that decreased end-tidal CO<sub>2</sub> by cardiopulmonary exercise testing predicts CSA in patients with HF.

**METHODS:** Consecutive ambulatory patients with New York Heart Association II to III HF were prospectively evaluated by CO<sub>2</sub> chemosensitivity by rebreath, cardiopulmonary exercise testing, and polysomnography (PSG). Subjects were classified as having either CSA (n = 20) or no sleep apnea (n = 13) by PSG; a central apnea-hypopnea index (AHI) ≥ 5 was used to define CSA. Subgroups were compared by *t* test or Mann-Whitney test and data summarized as mean ± SD. *P* < .05 was considered significant.

**RESULTS:** At rest, subjects with CSA had higher central CO<sub>2</sub> chemosensitivity ( $\Delta$ minute ventilation [ $\dot{V}_E$ ]/ $\Delta$ partial pressure of end-tidal CO<sub>2</sub> [PETCO<sub>2</sub>]),  $2.3 \pm 1.0$  L/min/mm Hg vs  $1.6 \pm 0.4$  L/min/mm Hg, *P* = .02) and  $\dot{V}_E$  ( $15 \pm 7$  L/min vs  $10 \pm 3$  L/min, *P* = .02) and lower PETCO<sub>2</sub> ( $31 \pm 4$  mm Hg vs  $35 \pm 4$  mm Hg, *P* < .01) than control subjects. At peak exercise, the ventilatory equivalents per expired CO<sub>2</sub> ( $\dot{V}_E/\dot{V}_{CO_2}$ ) was higher ( $43 \pm 9$  vs  $33 \pm 6$ , *P* < .01) and PETCO<sub>2</sub> lower ( $29 \pm 6$  mm Hg vs  $36 \pm 5$  mm Hg, *P* < .01) in subjects with CSA. In addition, CO<sub>2</sub> chemosensitivity, peak exercise  $\dot{V}_E/\dot{V}_{CO_2}$ , and PETCO<sub>2</sub> were independently correlated with CSA severity as quantified by the AHI (*P* < .05). Peak exercise PETCO<sub>2</sub> was most strongly associated with CSA (OR, 1.29; 95% CI, 1.08-1.54; *P* = .01; area under the curve, 0.88).

**CONCLUSIONS:** In patients with HF and CSA, ventilatory drive is increased while awake at rest and during exercise and associated with heightened CO<sub>2</sub> chemosensitivity and decreased arterial CO<sub>2</sub> set point.

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