Exercise echocardiography combined with cardiopulmonary exercise testing in cardiac rehabilitation

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Why combined Echo and CPET ?

- CPET :
  - Exercise capacity
  - Limitations : heart, peripheral muscles, ventilation
  - Ventilatory threshold
- Echocardiography:
  - LV and RV funtion
  - Estimation of pulmonary pressure

Phenotype

Published data CPET and ExEcho

- Cardiac contributions to exercise training responses in CHF
  - changes on peak VO2 is related to myocardial function at baseline

  = baseline strain and the improvement of strain after 8 weeks of ET

  (Smart N, Echocardiography,2006)

- Role of right ventricle and exercise ventilatory power
  - Δ VO2/ Δ WR flattening reflects an impaired functional phenotype (excessive sPAP and reduced peak longitudinal RV function)
  - EVP reflects worsening cardiopulmonary hemodynamic status (deteriorating RV function and pulmonary hemodynamics)

  (Guazzi M, Circ Heart Fail 2014, Intern J Cardiol 2014)

- Mitral regurgitation in HF
  - dynamic MR had a similar functional impairement to rest severe MR

  (Bandera F. Eur Hear J Cardiovasc imaging 2016)

Preliminary experience

- Patients underwent CPX using a 10 watts/min protocol performed on a tilt-table cycle ergometer combined with simultaneous Doppler echocardiographic assessment
- LVEF(volumetric analysis at 2 perpendicular apical views) and global strain, Filling pressures (E, A, e'), Right ventricular function : S wave, pulmonary artery systolic pressures
- 4 times : rest, VT1, peak exercise and 2 min recovery
- Recorded loops, storage and post-analysis
- Requirements : previous CPET (VT1 determination) and 2 cardiologists

Preliminary results

- **70 CHF patients** (LVEF 31 ± 10 %)

  57 ± 12 years, 86 % male, ischemic 51 %

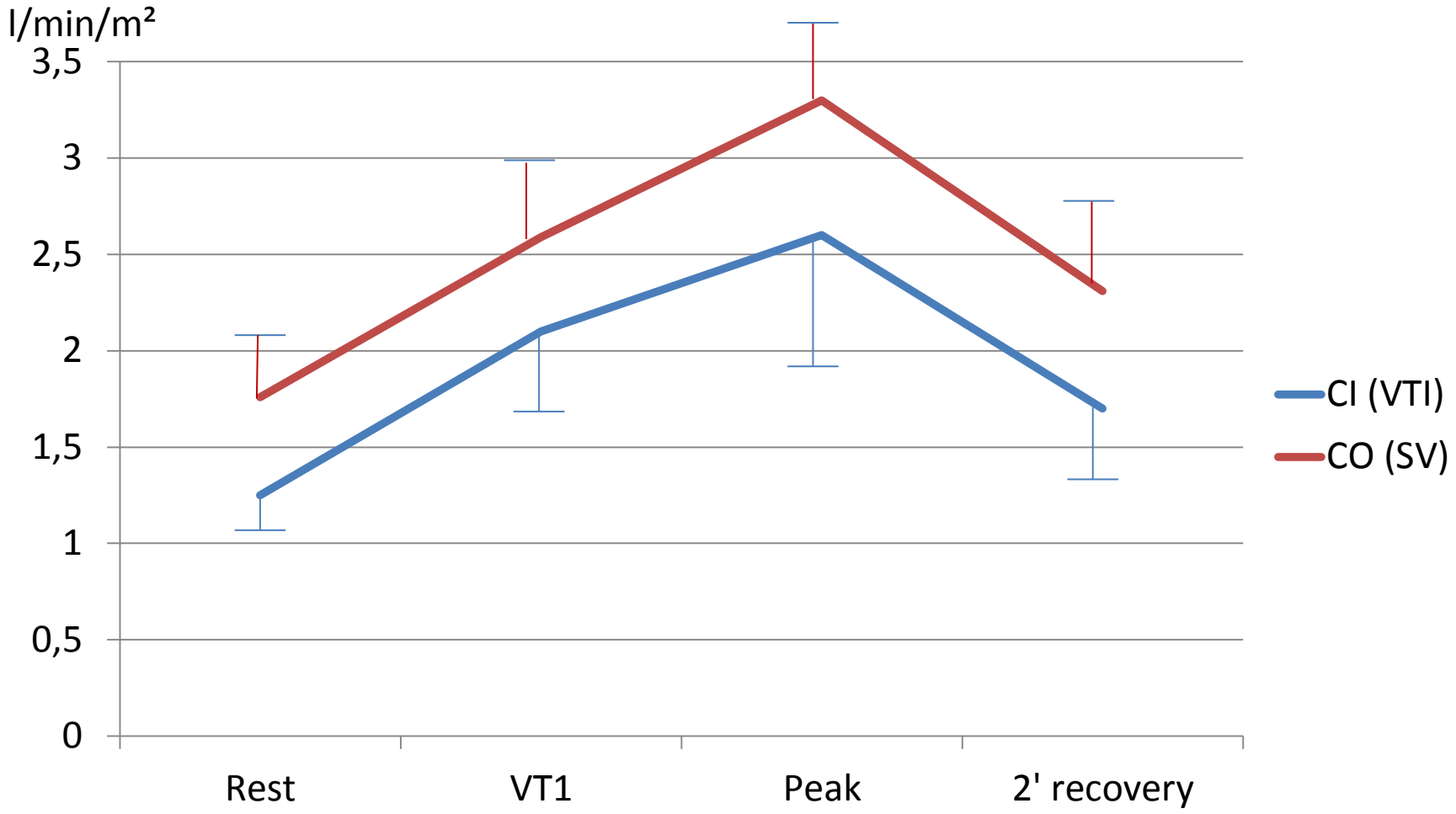
  GFR : 71±22 ml/min, Hb 13±2 g/dL, BNP 456±457 pg/ml

  Treatements :

Bblockers	90 %,
ACEi/ARB	88%,
Diuretics	57 %,
Antialdosterone	71%,
Ivabradine	11%,
CRT	15 %,
ICD	40%

  - CPET:
    - peak : 99 ± 37 watts, 18.1 ± 5.4 ml/kg/min
    - VT1 : 60 ± 27 watts, 12.1 ± 3.7 ml/kg/min

Preliminary results (echo)



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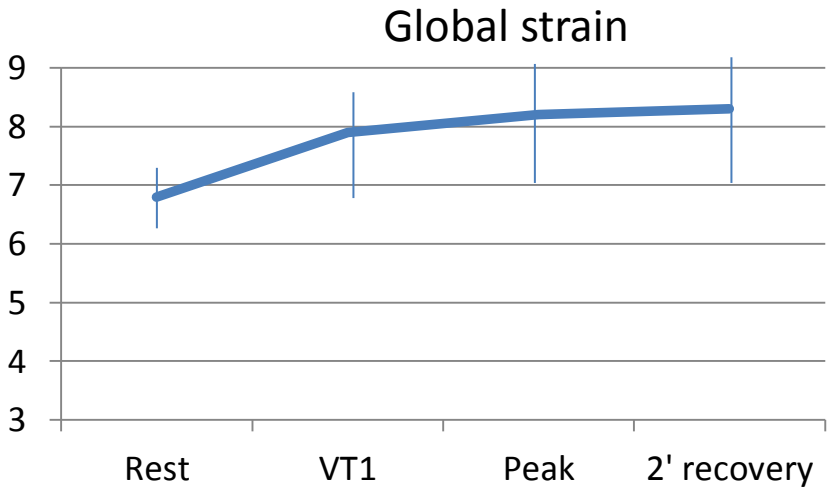
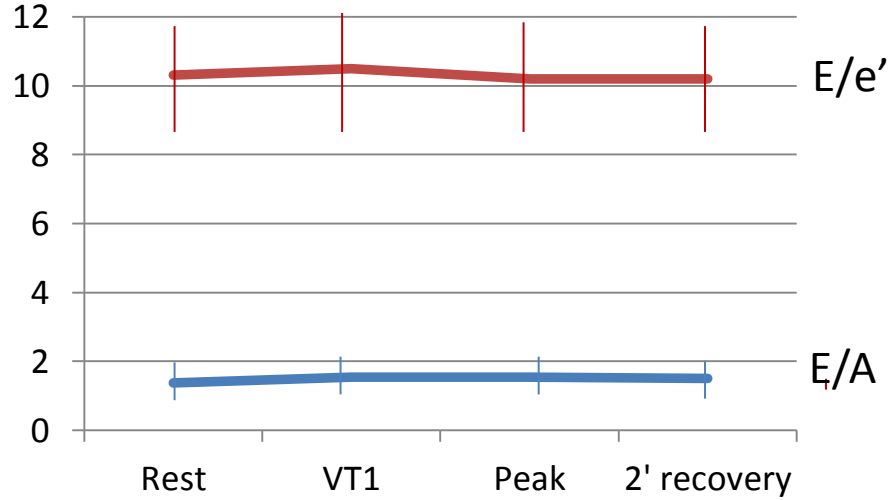
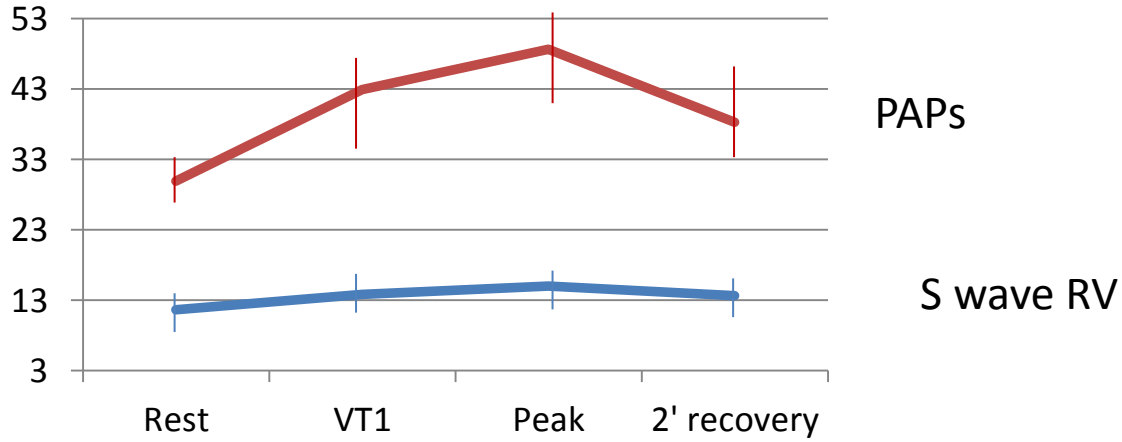
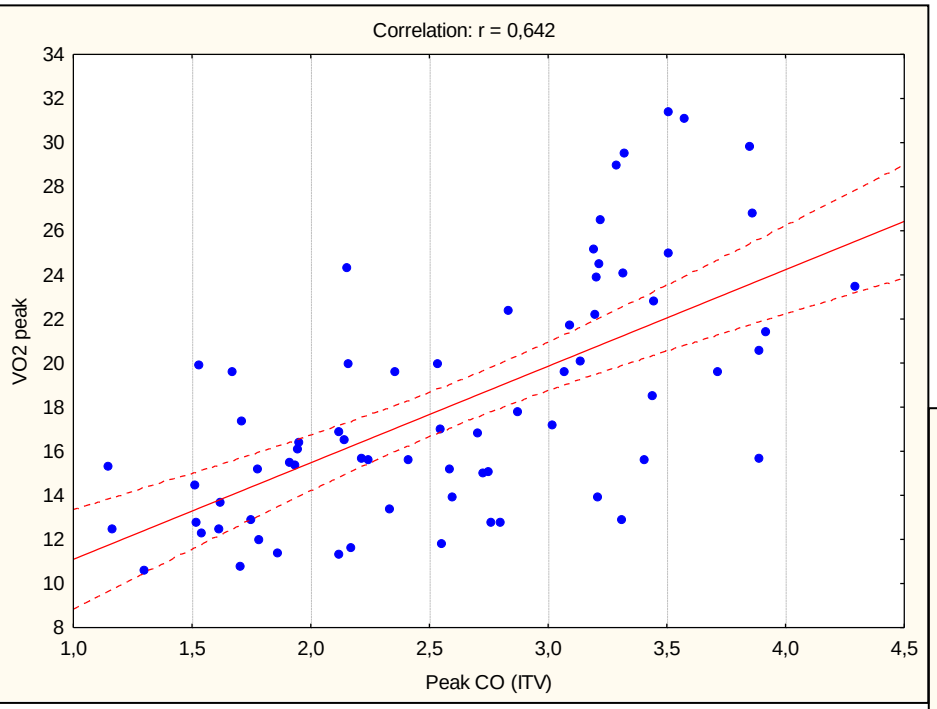
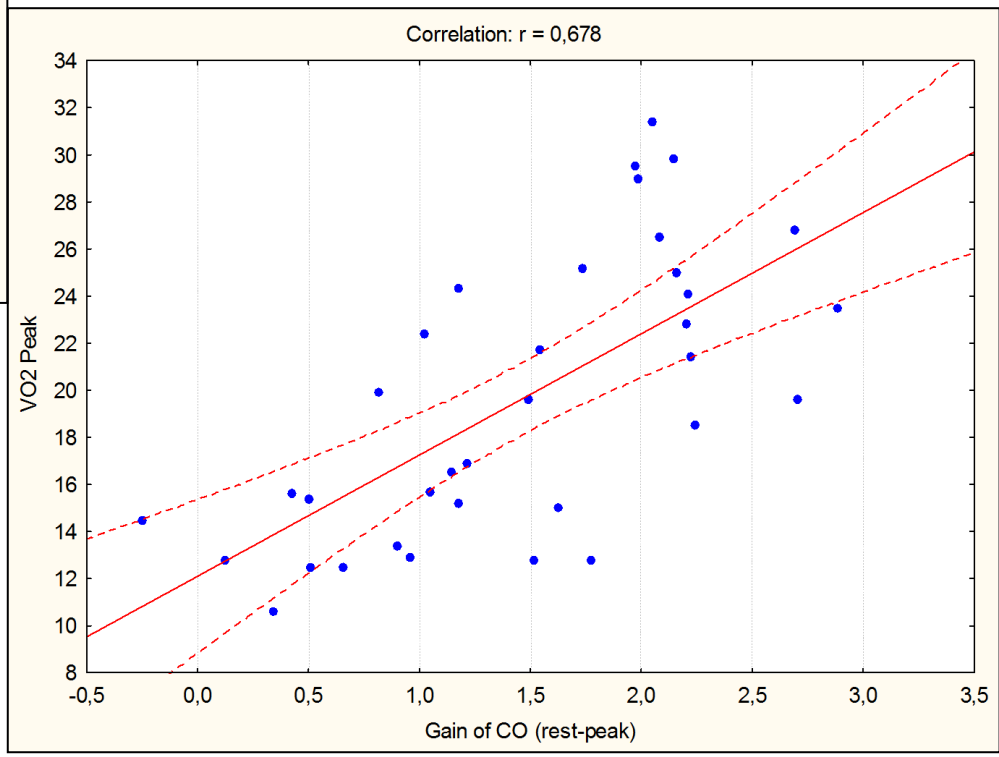






Correlation between peak VO2 and CI





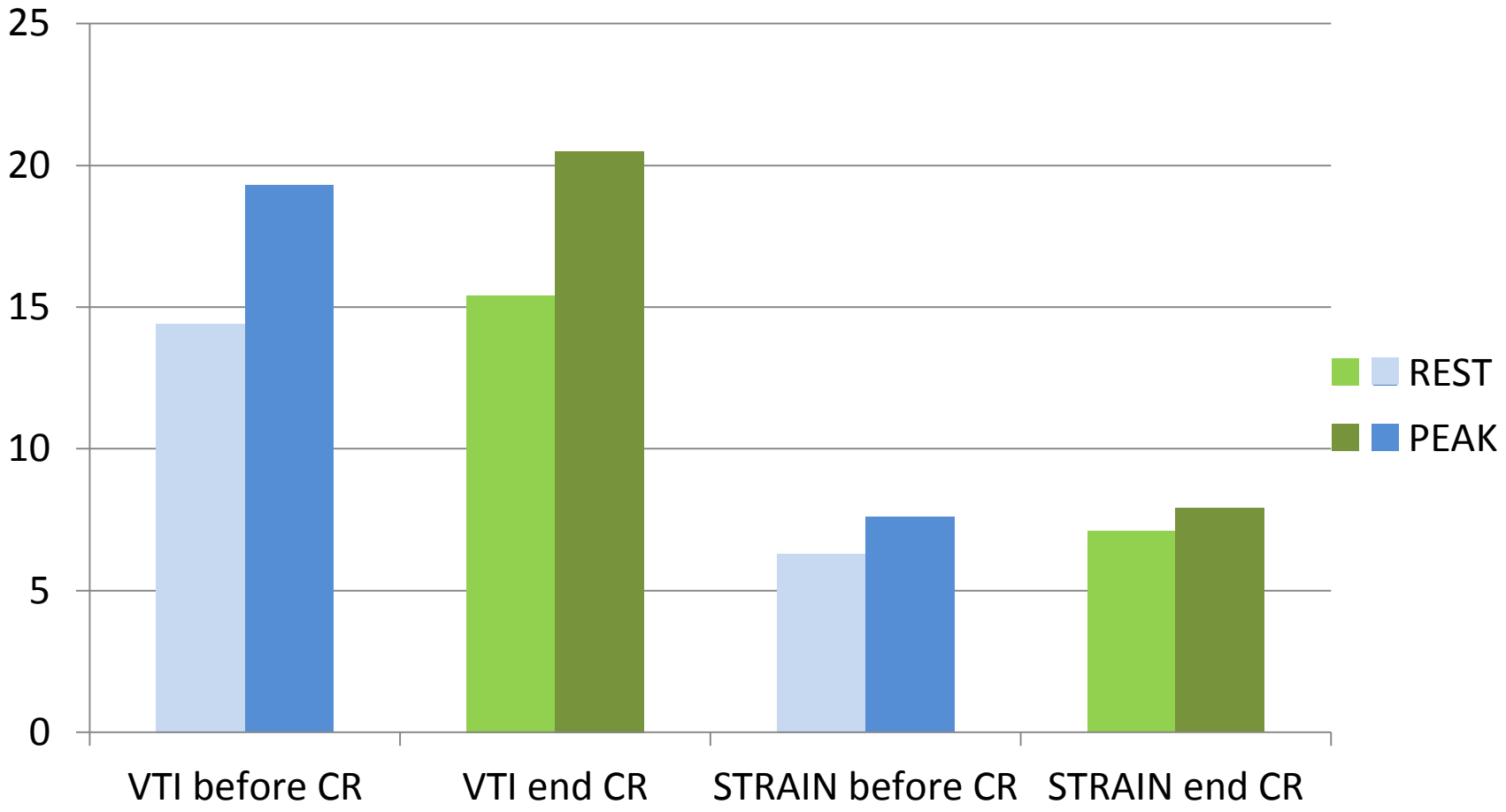
Changes of CI at exercise

	Delta CO > 1,5 l/min	Delta CO ≤ 1,5 l/min	p
Age	54.5 ± 11.5	59.0 ± 12	0,11
Hb	12.9 ± 1.7	12.5 ± 1.8	0,35
sBP	109 ± 13	108 ± 15	0,96
HR	63.2 ± 11.3	68.5 ± 14.8	0,22
VT1 watts	65.1 ± 30.5	54.8 ± 22.4	0,17
VT1 VO2	13.1 ± 4.5	11.2 ± 2.5	**0,07**
Peak sBP	167 ± 36	152 ± 43	**0,07**
Peak HR	115.0 ± 25.3	111.6 ± 20.7	0,46
Peak watts	107.3 ± 39.3	90.8 ± 33.8	**0,08**
Peak VO2	19.7 ± 6.3	16.6 ± 3.8	**0,04**
VE/VCO2 slope	37.7 ± 7.8	42.6 ± 9.9	**0,03**
Circulatory power (VO2 x BP)	3300 ± 1311	2538 ± 932	**0,01**
Ventilatory power (BP/VE/VCO2 slope)	4.6 ± 1.3	3.8 ± 1.4	**0,01**

Changes after CR program

- 22 CHF patients
- Ex Training : 18 sessions (75 % CT and IT, 25 % CT)
- Δ VO2 : 19,5 % (17,3 ± 5,8 vs 20,2 ± 6,4 ml/kg/min)
- Δ VT1 : 22 % (11,8 ± 3,9 vs 14,2 ± 4,4 ml/kg/min)

22 patients before and after CR



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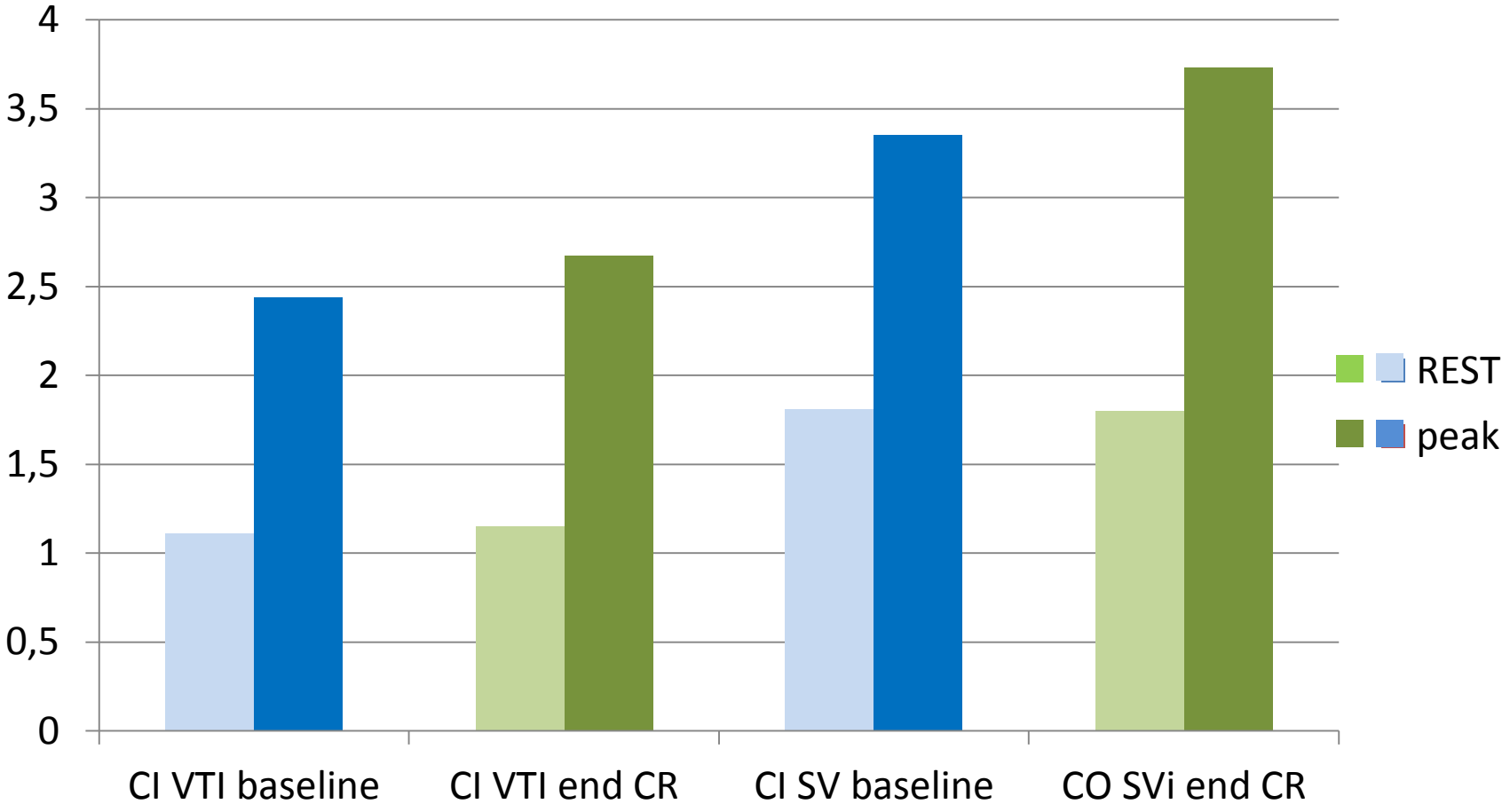

Gains of peak VO2

- **The responders of CR** (gain > 10 %) have significant improvements on
  - E/A at VT1
  - CO responses at VT1 and at peak exercise
- **The non responders of CR** (gain < 10 %) have significant differences by
  - Lower HR responses
  - Any significant changes on echoDoppler parameters
- E/A and E/e' responses to exercise at baseline are significantly correlated (r=0,8) with gains of VO2 after the exercise training program.

Perspectives

- Expand our experience including other non-invasive measures of cardiac output.
- Explore different exercise profiles in CHF patients (phenotypes).
- Secondarily compare diverse types of training according to the cardiac responses to exercise.

Conclusion

- EchoDoppler combined with CPET is feasible
- Require expertise, specific material, and time

- May be useful to understand better the variations of hemodynamic response to the effort, its limitations, and to adapt the exercise training in our CR programs