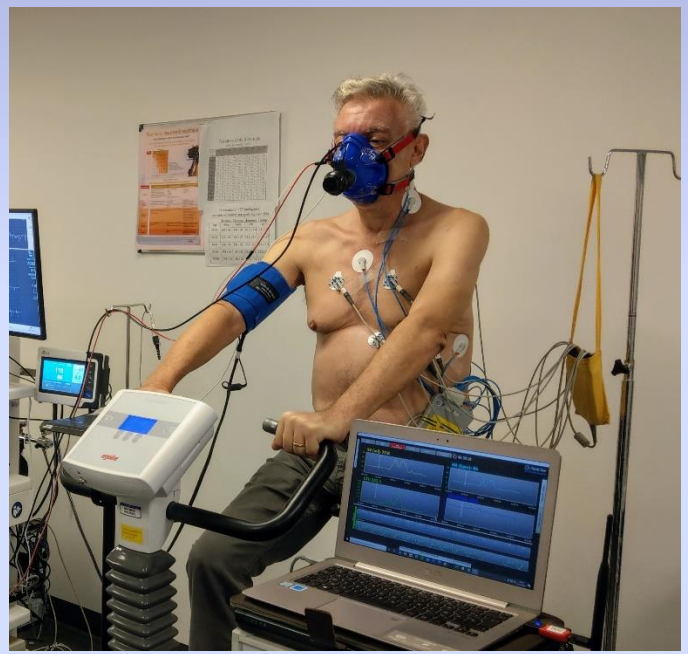
Clinical Benefits of Advanced Signal Morphology - Impedance Cardiography (SM-ICG)



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Exercise Physiology and Cardiac Rehabilitation

Important Disclaimer: This presentation reflects the opinion of a practitioner about the applications of the technology and not the official claims by Manatec Biomedical/ PhysioFlow regarding the clinical applications/benefits of their technology

Clinical Benefit 1: Early Detection of Hemodynamic/Cardiovascular Abnormalities

- ✓ Earlier detection means better outcomes
- ✓ Standard of care technology has limited screening capacities, because:
  - invasive (catheters)
  - operator- and/or patient- dependent (echo/stress echo)
  - uses surrogate imprecise measures (VO2)
  - lack of sensitivity (stress ECG)
  - expensive (PET Scan)

* Eur J Intern Med 2008 Oct;19(6):399-405. doi: 10.1016/j.ejim.2007.07.007. Epub 2008 Feb 11.

Impedance cardiography: a rapid and cost-effective screening tool for cardiac disease

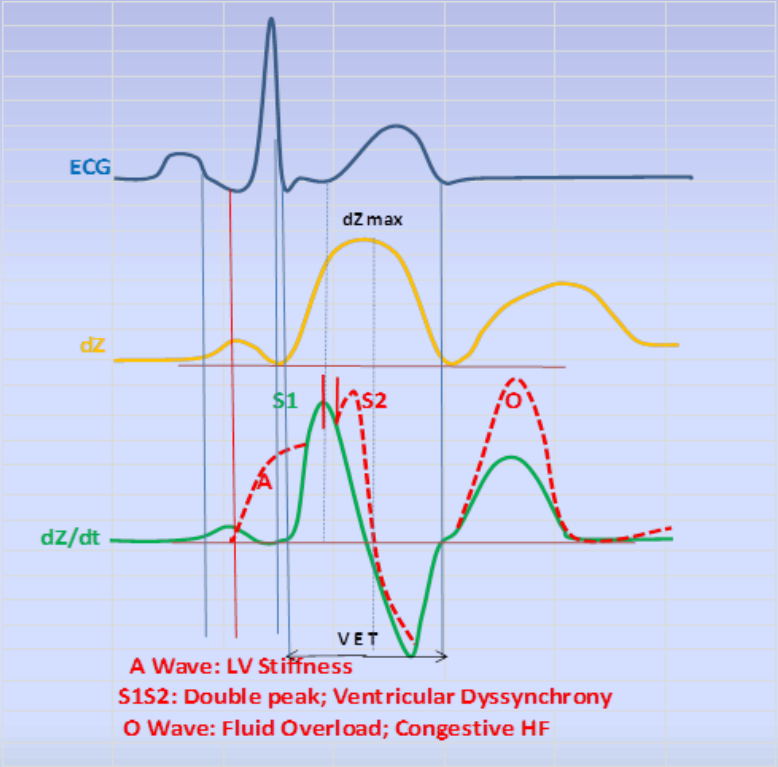
Jean Bour 1 , John Kellett

* Int Heart J 2012;53(5):293-8. doi: 10.1536/ihj.53.293.

Cardiac output response to exercise in chronic cardiac failure patients

Taira Fukuda 1 , Akihiro Matsumoto, Miwa Kurano, Haruhito Takano, Haruko Iida, Toshihiro Morita, Hiroshi Yamashita, Yasunobu Hirata, Ryozo Nagai, Toshiaki Nakajima

A new modality for screening : Signal Waveform Abnormalities Analysis



- **Double S peak:**
  Ventricular dyssynchrony (consider BIV pacing)

- **Elevated O wave:**
  Fluid overload as a consequence of Congestive Heart Failure (consider diuretics)

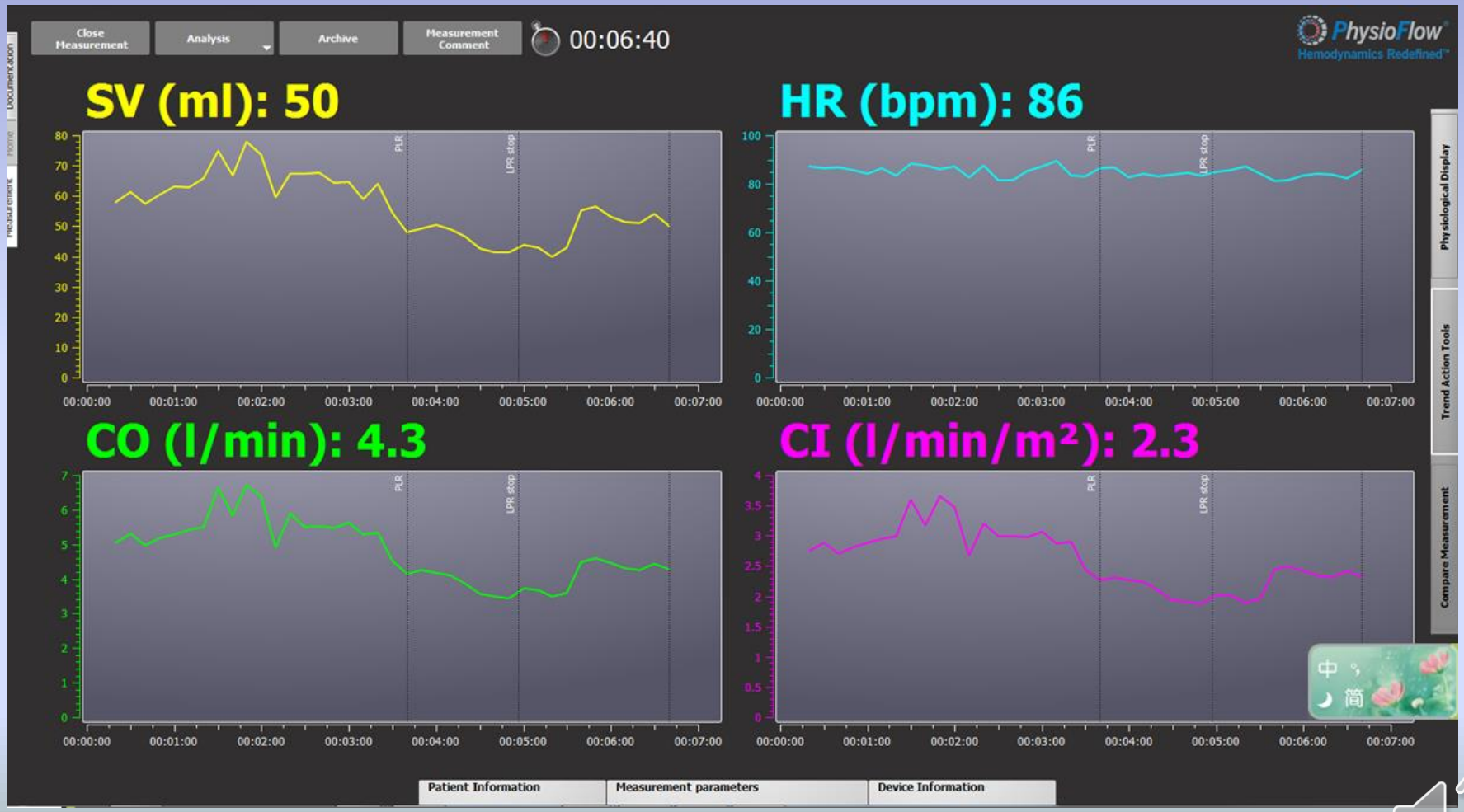
- **Elevated A wave:**
  Ventricular stiffness, frequent in case of hypertrophic heart (diastolic dysfunction)

Case Study 1 – Diastolic Dysfunction

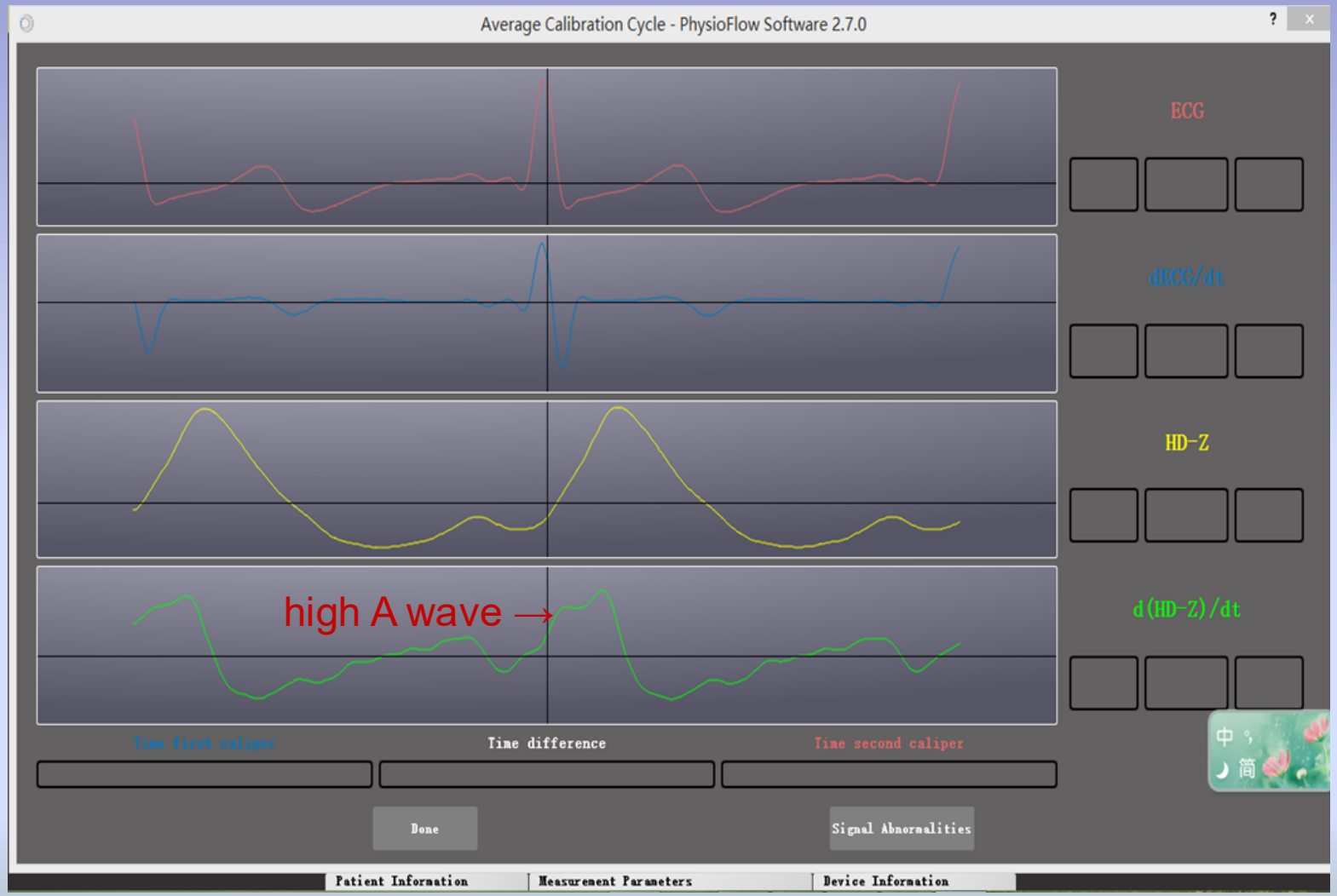
- 54yo Female, with history of poorly controlled hypertension
- BP: 128/88 mmHg

Passive Leg Raising test

SV decreases when preload increases : fluid overload (Frank-Starling) or diastolic dysfunction?

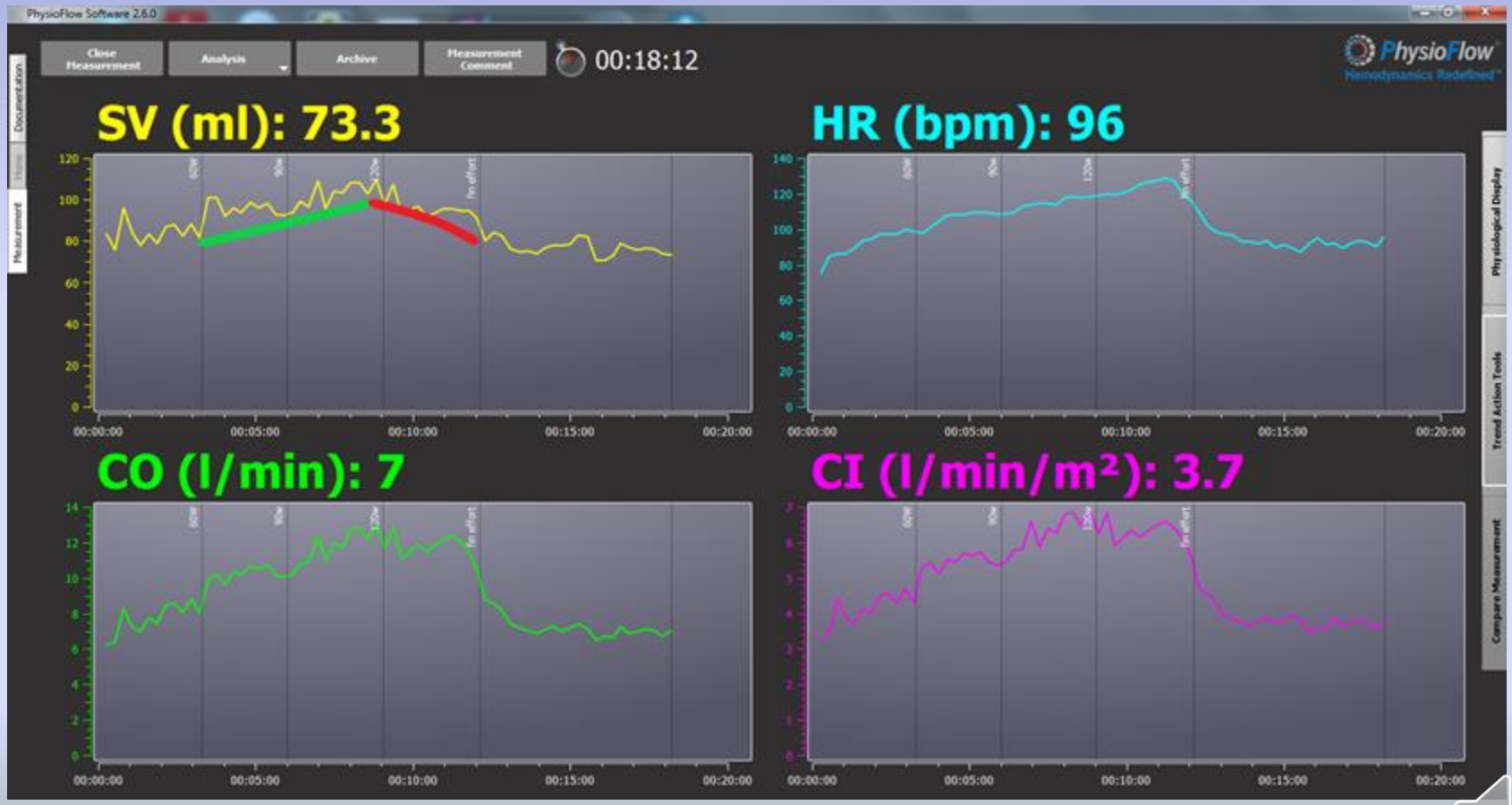


The underlying issue: a late diastolic A Wave, sign of diastolic dysfunction



Case Study 2 – Sensitive detection of CAD

- 56 yo Male, risk factors for CAD, LBBB (no ST segment)
- SV decreases at 120 watts after having increased normally = ischemia
- No false negatives



Clinical Benefit 2 : Optimized treatment interventions

✓ Better understanding of the nature and status of the hemodynamic/cardiovascular abnormality (in hypertension, heart failure...), at rest and DURING EXERCISE

→ More precise and personalized treatment interventions (drug, rehabilitation, pacing…).

***** European Heart Journal, Volume 39, Issue suppl_1, August 2018, ehy566.P6061, https://doi.org/10.1093/eurheartj/ehy566.P6061

Published:28 August 2018

Changes in exercise capactiy of frailest patients with heart failure treated with standard exercise recommandations versus stroke volume response to exercise: a pilot study

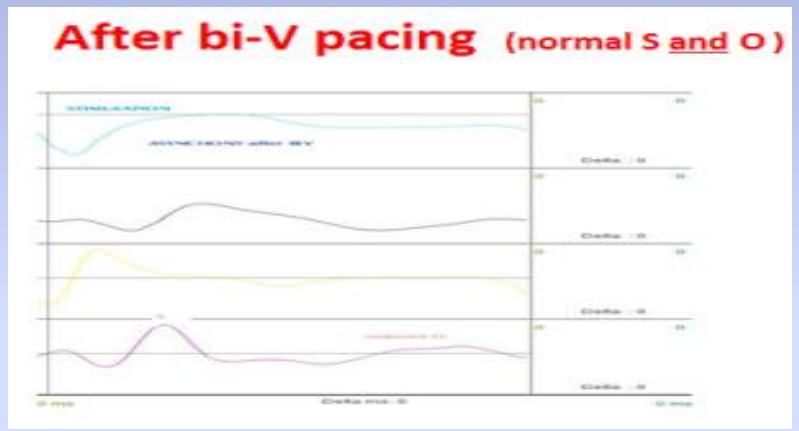
P-M Lepretre, A Poty, T Porcher, F Hermel, A L Germain, F Krim, A L Gugenheim, Y Garaud

* Bour F, Milstein E, Poty A, Garaud Y, Vitiello D, Leprêtre PM. Signal-morphology impedance cardiography is a non-invasive tool for predicting responses to exercise-based cardiac rehabilitation. Int J Cardiol. 2025 Jan 15;419:132670. doi: 10.1016/j.ijcard.2024.132670. Epub 2024 Oct 24. PMID: 39454687.

Case study 1: Collecting Info for Therapeutic Intervention

1. PhysioFlow does help in collecting useful data to optimize and monitor therapeutic interventions
2. This information is much easier to obtain, repeat and handle than Echo and VO2 test

Example, ventricular dyssynchrony (CRT pacing)

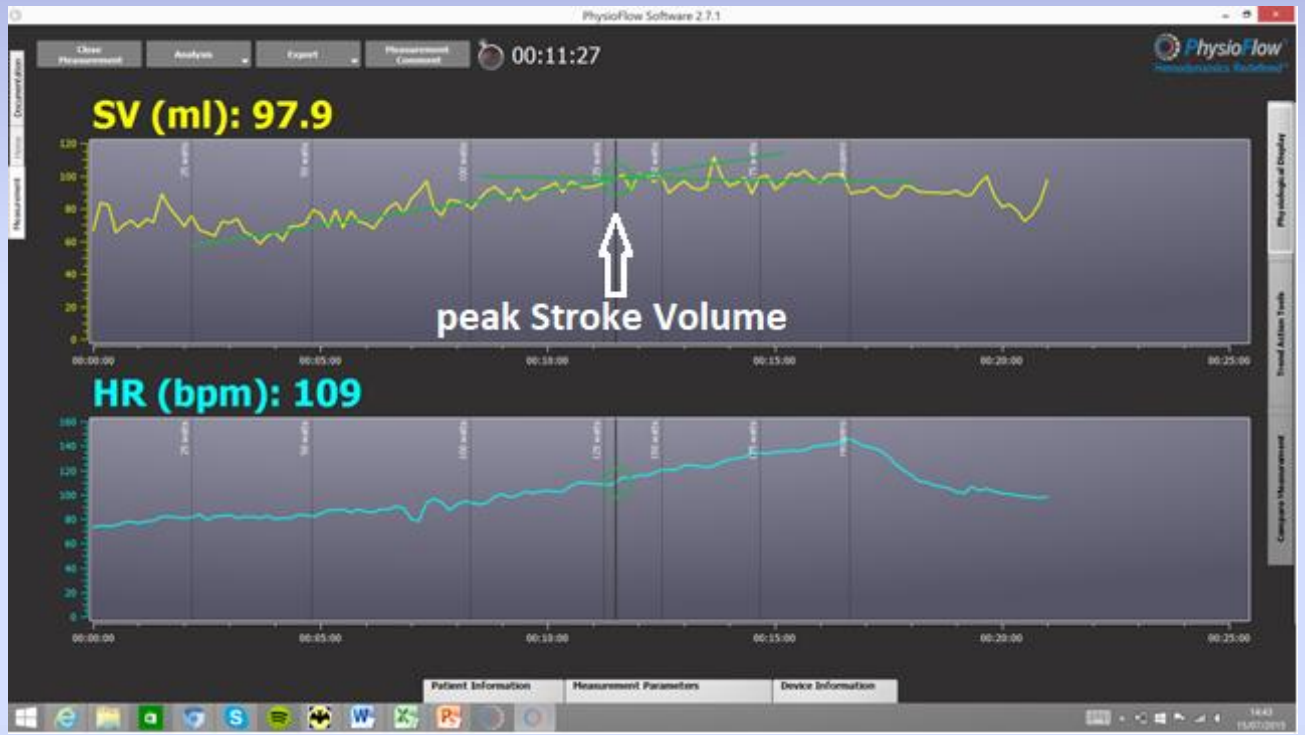


Case study2: Determination of the peakSV

Protocol: ramp test on a cyclo-ergometer.

Initial test warmup no load, 60 rpm, 3 mins
Increment 15 w/min max for women, 20 w/min max for men

The peakSV level is the heart rate level (or workload) at which the rapid ascend in SV turns into a slow increase or even a plateau. In this example it was HR=109 bpm



- This peakSV level can then be used to “calibrate” individual training protocols in cardiac rehabilitation

Clinical Benefit 3 : Predictive value

- ✓ Advanced Signal Morphology ICG enables a significantly better prediction of potential worsening of heart failure after a cardiopulmonary exercise test as compared with the same test performed without PhysioFlow (ECG alone or even ECG combined with VO2).

→ Cut-off value at Max exercise : CI < 7.5 $l.min^{-1}.m^{-}$

* Eur Heart J. 2018 Apr 7;39(14):1144-1161.doi: 10.1093/eurheartj/ehw180.
2016 focused update: clinical recommendations for cardiopulmonary exercise testing data assessment in specific patient populations
Marco Guazzi, Ross Arena, Martin Halle, Massimo F Piepoli, Jonathan Myers, Carl J Lavie

* BMC Sports Sci Med Rehabil. 2022 Jul 17;14(1):134. doi: 10.1186/s13102-022-00527-w.
Cardiopulmonary exercise testing and impedance cardiography in the assessment of exercise capacity of patients with coronary artery disease early after myocardial revascularization
Małgorzata Kurpaska 1 , Paweł Krzesiński 2 , Grzegorz Gielerak 2 , Karina Gołębiewska 2 , Katarzyna Piotrowicz 2

- J Card Fail. 2013 Feb;19(2):101-7.doi: 10.1016/j.cardfail.2012.11.010.

Cardiopulmonary and noninvasive hemodynamic responses to exercise predict outcomes in heart failure

Jonathan Myers 1 , Myo Wong, Chandana Adhikarla, Madhavi Boga, Sridevi Challa, Joshua Abella, Euan A Ashley

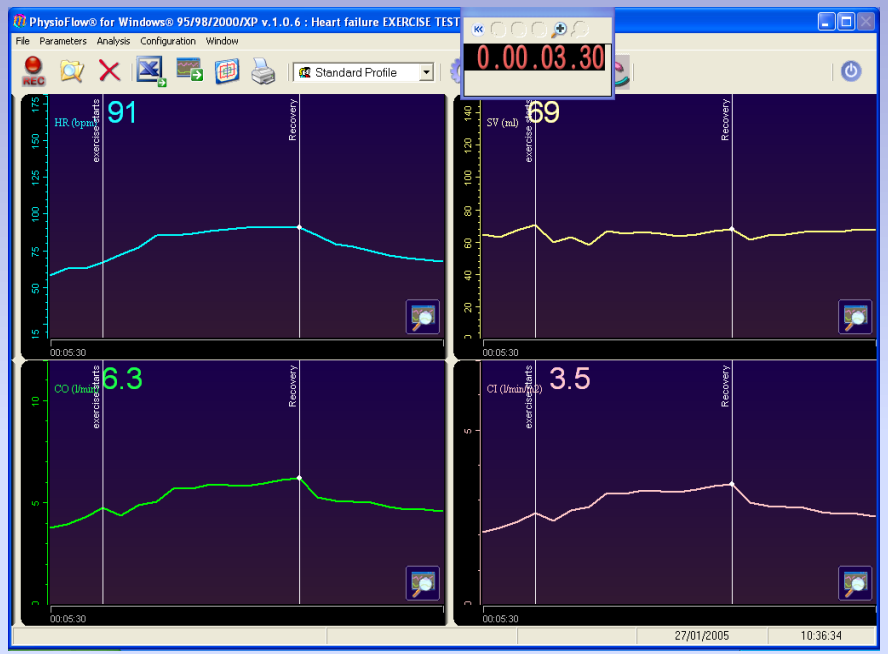
* JACC Heart Fail. 2015 May;3(5):408-418. doi: 10.1016/j.jchf.2014.11.011. Epub 2015 Apr 8.

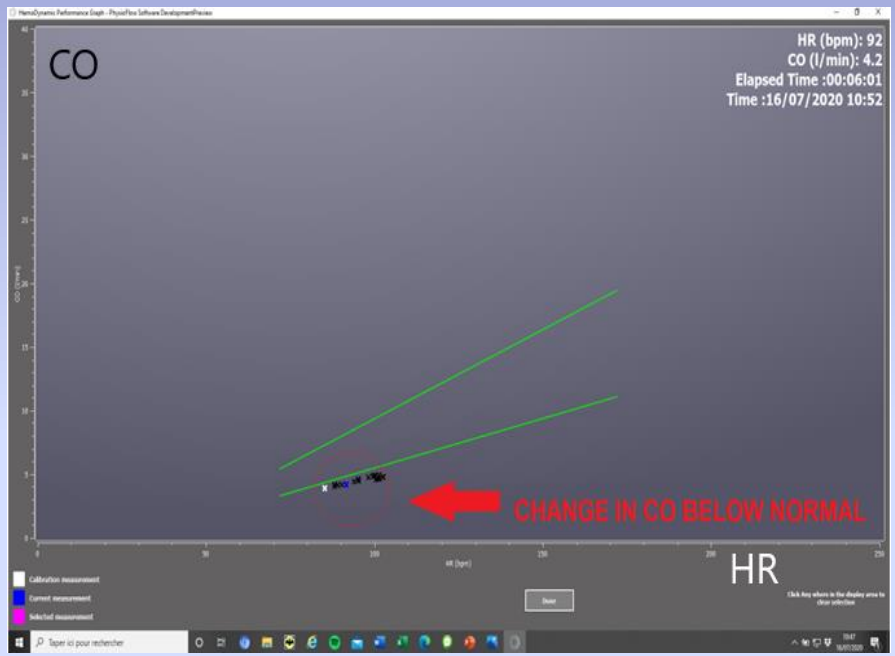
Cardiopulmonary responses and prognosis in hypertrophic cardiomyopathy: a potential role for comprehensive noninvasive hemodynamic assessment

Gherardo Finocchiaro 1 , Francois Haddad 2 , Joshua W Knowles 2 , Colleen Caleshu 3 , Aleksandra Pavlovic 3 , Julian Homburger 3 , Yael Shmargad 3 , Gianfranco Sinagra 4 , Emma Magavern 3 , Myo Wong 5 , Marco Perez 3 , Ingela Schnittger 2 , Jonathan Myers 5 , Victor Froelicher 5 , Euan A Ashley 6

Exercise Test in HF Patient

No increase in SV = severely depressed cardiac function





PhysioFlow can double the predictive value of an exercise test in HF

Clinical Benefit 4 : Differential diagnosis

- ✓ The fourth benefit of PhysioFlow is to enable differential diagnosis when the cause of certain exercise restrictions or clinical condition remains unclear (for instance checking the heart function in dyspnoeic and/or Covid patient, non-responders to cardiac rehabilitation etc.).

* Hypertens Res. 2019 Feb;42(2):211-222.
doi: 10.1038/s41440-018-0145-y. Epub 2018 Nov 30.
Exercise impedance cardiography reveals impaired hemodynamic responses to exercise in hypertensives with dyspnea
Małgorzata Kurpaska 1 , Paweł Krzesiński 2 , Grzegorz Gielerak 2 , Beata Uziębło-Życzkowska 2 , Małgorzata Banak 2 , Adam Stańczyk 2 , Katarzyna Piotrowicz 2

* Emerg Med J 2010 May;27(5):359-63.doi: 10.1136/emj.2009.073437.
Thoracic electrical bioimpedance: a tool to determine cardiac versus non-cardiac causes of acute dyspnoea in the emergency department
Christiane Vorwerk 1 , Hanusha Jeyanithi, Timothy J Coats

Clinical Benefit 5 : Measuring Outcomes

- ✓ The individual and patient group treatment outcomes are monitored efficiently with PhysioFlow (which is a reproducible and sensitive technology).
- ➢ There is an increased demand by health insurances to document outcomes (accountable care)

- * Int J Cardiol 2021 May 1;330:120-127.doi: 10.1016/j.ijcard.2021.02.004. Epub 2021 Feb 9.

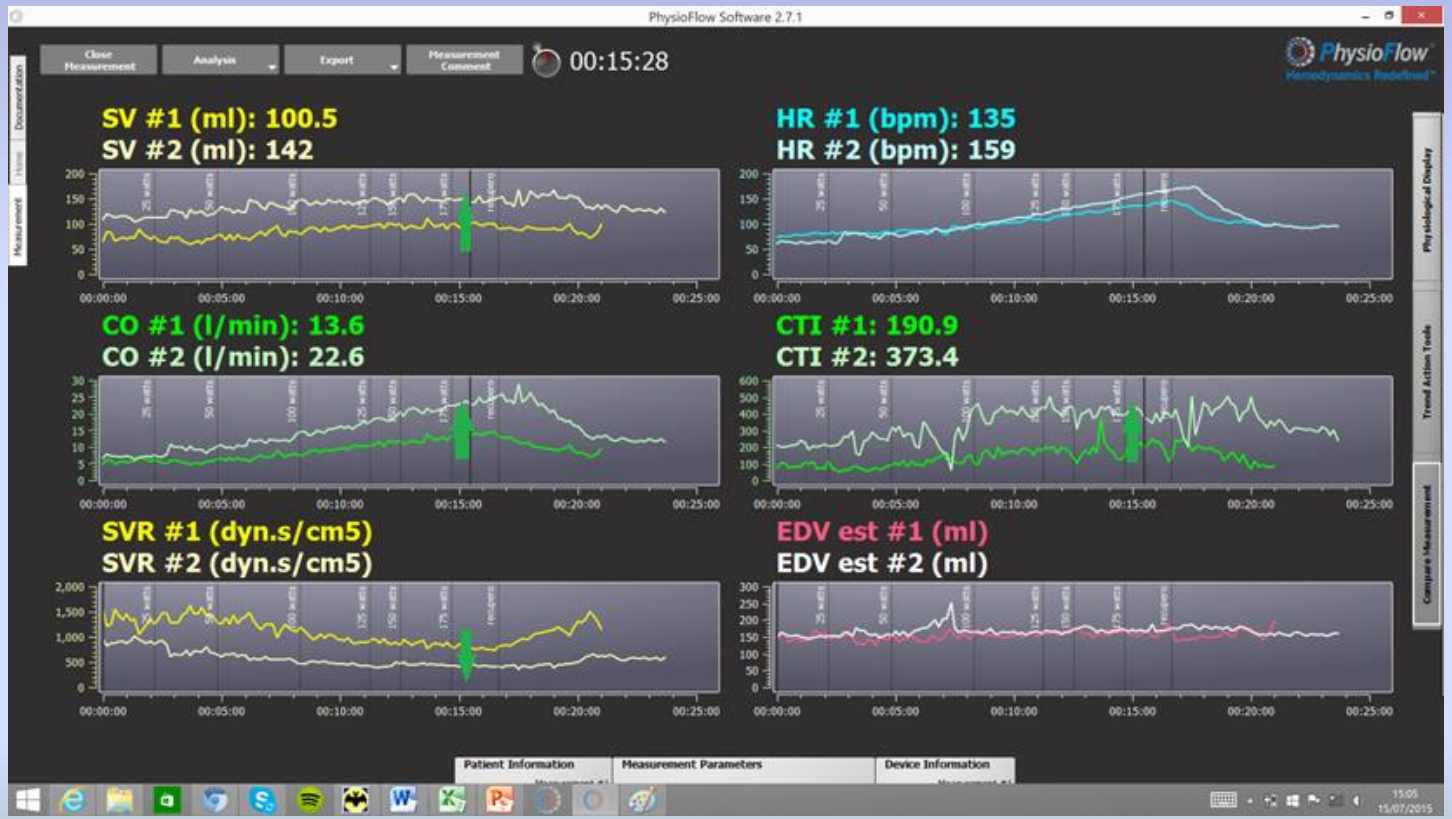
Responses to exercise training in patients with heart failure. Analysis by oxygen transport steps

Antoine Legendre 1 , Feriel Moatemri 2 , Oksana Kovalska 2 , Maria Balice-Pasquinelli 2 , Jean-Christophe Blanchard 2 , Aurelia Lamar-Tanguy 2 , François Ledru 2 , Pascal Cristofini 2 , Marie-Christine Iliou 2

Case study: Therapy Evaluation

Example of Cardiac Rehab Evaluation:

Test/re-test before after rehab program (all hemodynamic parameters improve)



Clinical Benefit 6 : Reducing the use of invasive technologies

- ✓ The sixth benefit of PhysioFlow is to limit the use of invasive diagnosis in cases where they are normally prescribed, while offering a noninvasive alternative, as a first step in routine evaluations (for instance partially replacing the use of Swan-Ganz catheter in pulmonary hypertension patients).

* Respiration. 2018;96(6):500-506. doi: 10.1159/000486423. Epub 2018 Feb 9.

Determination of Cardiac Output in Pulmonary Hypertension Using Impedance Cardiography

Marion Dupuis 1 , Elise Noel-Savina 2 , Gregoire Prévot 2 , Laurent Tétu 2 , Fabien Pillard 3 , Daniel Rivière 3 , Alain Didier 2

* Clin Respir J. 2019 Apr;13(4):222-231. doi: 10.1111/crj.13002. Epub 2019 Feb 28.

Cardiac output measurement during exercise in COPD: A comparison of dye dilution and impedance cardiography

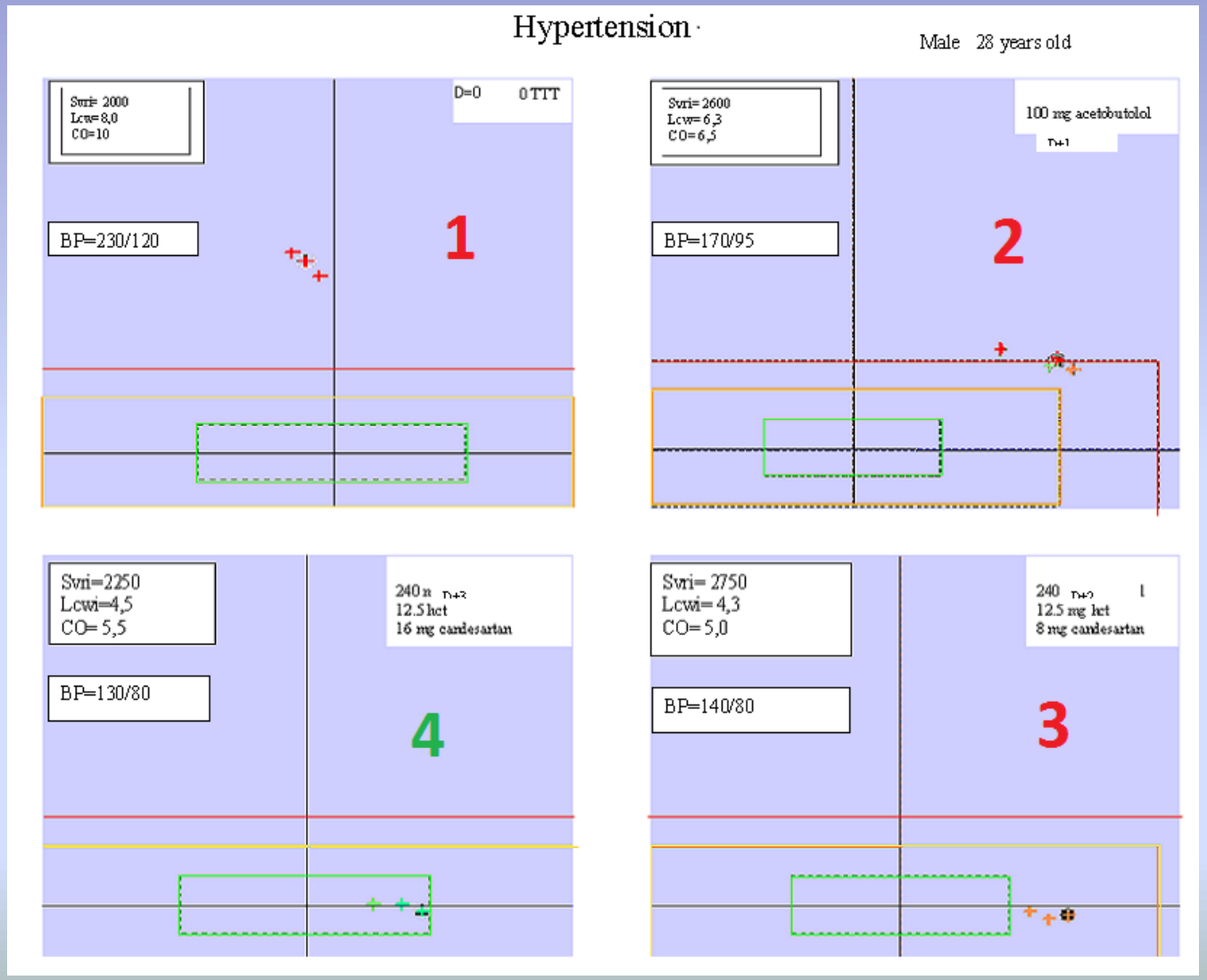
Zafeiris Louvaris 1 2 3 , Stavroula Spetsioti 2 , Vasileios Andrianopoulos 4 , Nikolaos Chynkiamis 2 5 , Helmut Habazettl 6 7 , Harrieth Wagner 8 , Spyros Zakynthinos 2 , Peter D Wagner 8 , Ioannis Vogiatzis 2 3 5

Clinical Benefit 7 : Avoiding Mistakes

- ✓ The seventh benefit of PhysioFlow is to point to potentially misleading information provided by other technologies (for instance VO2 testing), in order for practitioners to think twice before they make a clinical decision.

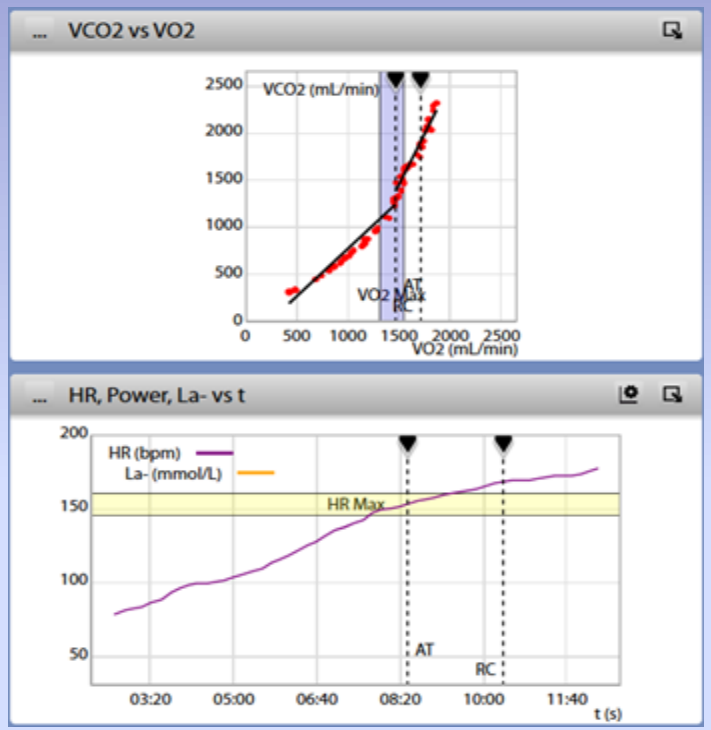
* J Card Fail. 2019 Dec;25(12):961-968. doi: 10.1016/j.cardfail.2019.08.013. Epub 2019 Aug 24.
Cardiopulmonary Exercise Testing, Impedance Cardiography, and Reclassification of Risk in Patients Referred for Heart Failure Evaluation
Jonathan Myers 1 , Jeffrey W Christle 2 , Amanda Tun 3 , Bilge Yilmaz 4 , Kegan J Moneghetti 2 , Elizabeth Yuen 3 , Muhammad Soofi 5 , Euan Ashley 2

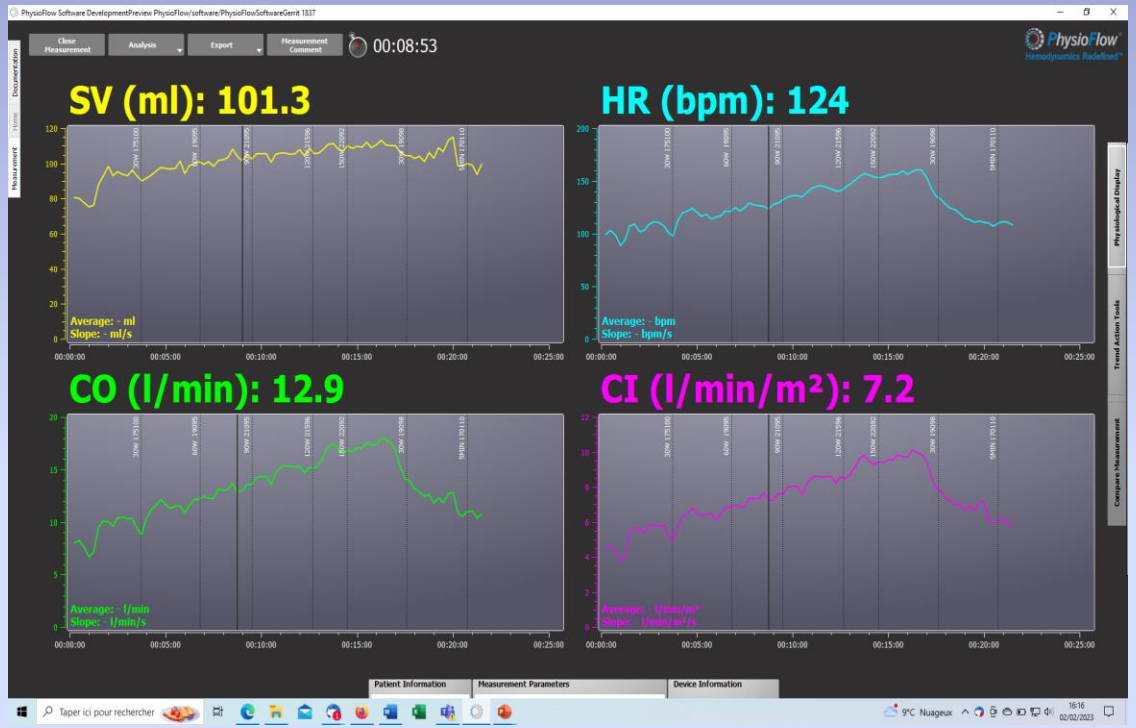
Case study :Drug Therapy Follow Up in Hypertension. The Hemodynamic Cross in Use



Case study: Correcting Miscalibration of Training Protocols

Cardiac rehab. patient, male 42 yo, post stenting





- VT1 (AT) detected by VO2 testing at a HR = 152 bpm and used for training level
  - ➢ Patient complained of it being too hard leading of rapid exhaustion

- PhysioFlow showed a peakSV threshold at HR = 124 bpm.
  - ➢ Training was readjusted accordingly, and well tolerated by the patient

Take Home Message:

- The PhysioFlow technology can benefit virtually all patients with known or suspected cardiovascular diseases or dysfunction, in many ways:

✓Noninvasive

✓Sensitive

✓Predictive

✓Easy to use and cost effective

✓Clinically recommended