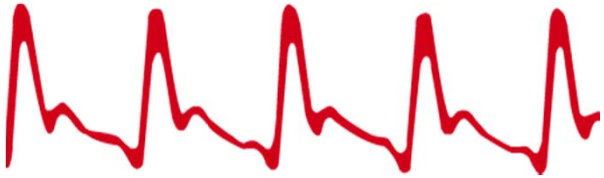
CNAP® HD (NIBP100D-HD) IN RESEARCH

Benefits in Research
20.10.2015, V3.2

One finger sensor providing complete cardiovascular responses to tests – continuous & non invasive

SETUP & PARAMETERS



BP

SVR

CO

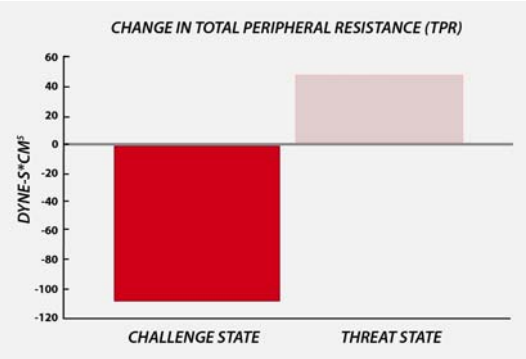
Unique combination of noninvasive continuous…

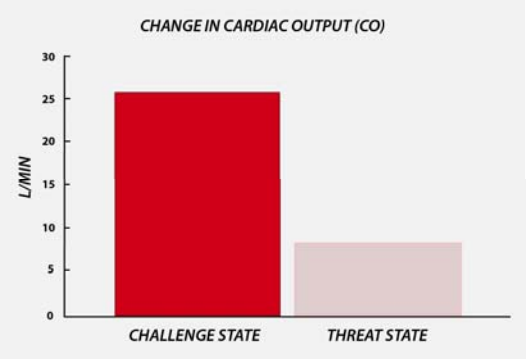
- Pulse Rate ✓
- Blood Pressure ✓
- Cardiac Output, Stroke Volume ✓
- Systemic Vascular Resistance ✓

Blood pressure, cardiac output and vascular resistance are used to differentiate between psychophysiological states.

WHY CONTINUOUS BP, CO & SVR IN RESEARCH ?

- Assessment of cardiovascular response to (psycho)physiolog. states
  - Reactions of the human body to ***challenge and threat*** (positive and negative stress) [1,2]





  - Quantification of ***emotional response*** [3]

[1] Kirby, L. D., & Wright, R. A. (2003). Cardiovascular correlates of challenge and threat appraisals: A critical examination of the Biopsychosocial Analysis. *Personality and Social Psychology Bulletin*, 7, 216-233.
[2] Tomaka, J., **Blascovich, J**., Kelsey, R. M., & Leitten, C. L. (1993). Subjective, physiological, and behavioral effects of threat and challenge appraisal. *Journal of Personality and Social Psychology*, 65, 248-260.
[3] Lackner, H. K., Weiss, E. M., Schulter, G., Hinghofer-Szalkay, H., Samson, A. C., & Papousek, I. (2013). I got it! Transient Cardiovascular Response to the Perception of Humor. *Biological Psychology*, *93*, 33–40.

Full hemodynamics and simple setup brings huge benefits for scientific studies

FEATURES & BENEFITS OF CNAP® HD IN RESEARCH

SIMPLE AND QUICK SET-UP

- One finger sensor provides all parameters **noninvasively** – no placing of catheters or additional electrodes.

QUICK RECORDING

- Signals displayed only shortly after startup
- enables accurate & immediate feedback on arterial BP, cardiac output, fluid and hemodynamic status, etc.

CLINICALLY PROVEN AND VALIDATED [1,2]

- Combination of finger sensor with NBP calibration provides high accuracy BP signal
- Continuity, accuracy & waveform dynamics are equivalent to intra-arterial measurement.
- Proven solution for consistent, repeatable results

SIMPLE DATA TRANSFER AND ANALYSIS

- Up to 4 analog output channels (BP waveform, MAP, CO*, PPV*)
- Plug & play integration into all common data acquisition systems (e.g. MP150: Acq*Knowledge*) and subject monitors.

[1] Jeleazcov et al.(2010). Precision and accuracy of a new device (CNAP) for continuous noninvasive arterial pressure monitoring: assessment during general anaesthesia. *British Journal of Anaesthesia*, 105(3):264–72.
[2] Wagner, J. Y. et al. Continuous noninvasive cardiac output determination using the CNAP system: evaluation of a cardiac output algorithm for the analysis of volume clamp method-derived pulse contour. *Journal of ClinicalMonitoring and Computing*. doi:10.1007/s10877-015-9744-1 (2015).

*CE approval granted; FDA approval pending;

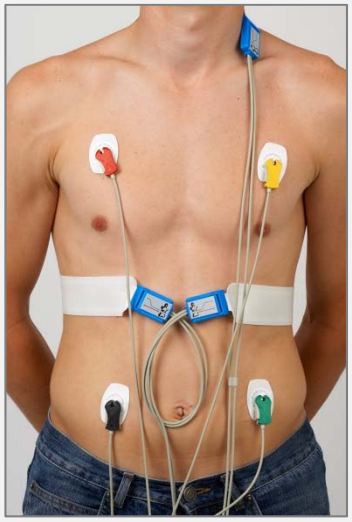
CNAP® HD provides easy setup for cardiac output from the same finger sensor

WAYS TO MEASURE CO IN RESEARCH

CNAP® HD

- Quick & simple setup
- Using a reusable finger sensor

Standard Impedance Cardiography



- Complex and time-consuming setup requires to undress upper body
- Placing of disposable electrodes

CNAP® HD combines three core technologies

HOW DOES CNAP® HD WORK?

COMBINATION OF 3 TECHNOLOGIES/METHODS:

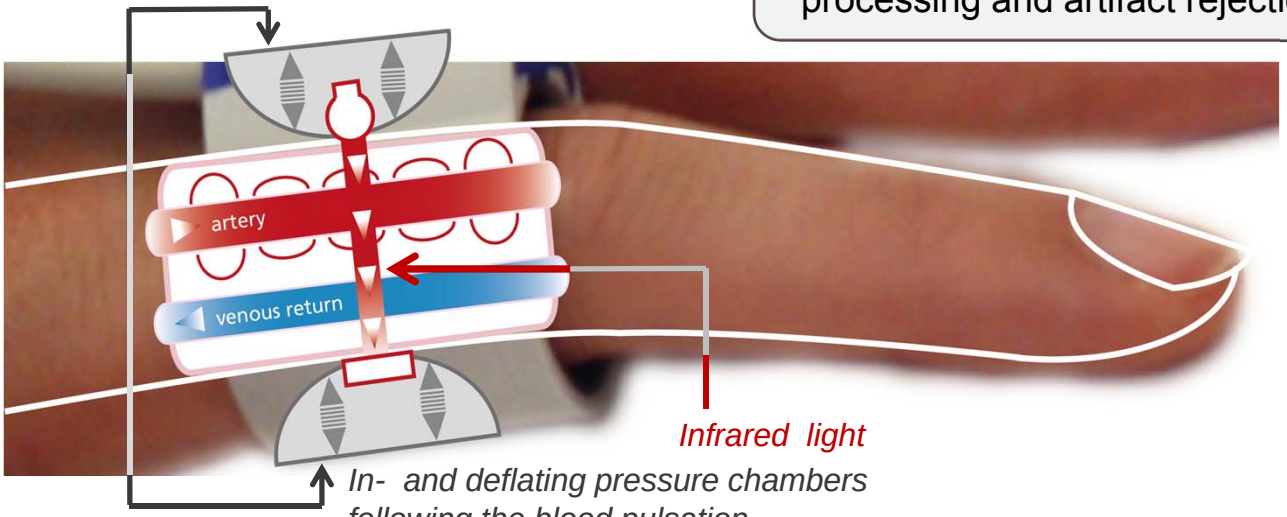
1. ***Vascular unloading principle***
   - Blood pressure, pulse rate from finger sensor
2. ***Standard upper arm cuff for calibration (NBP)***
   - Reference BP value at heart level for automatic scaling
3. ***Pulse Contour Analysis (PCA)***
   - SV, CO, SVR

BIOPAC® Systems, Inc.
WWW.BIOPAC.COM

Integrated pressure chambers measure blood pressure continuously

CONTINUOUS BLOOD PRESSURE

1. Infrared light sensors pick up blood volume and flow.
2. In- and deflating pressure chambers follow blood pulsation and keep blood flow constant. The resulting pressure in the finger sensor corresponds to the real arterial pressure.[1]
3. The pressure system is controlled by multiple digital feedback loops and the “VERIFI-algorithm” for high fidelity signal processing and artifact rejection.[2]



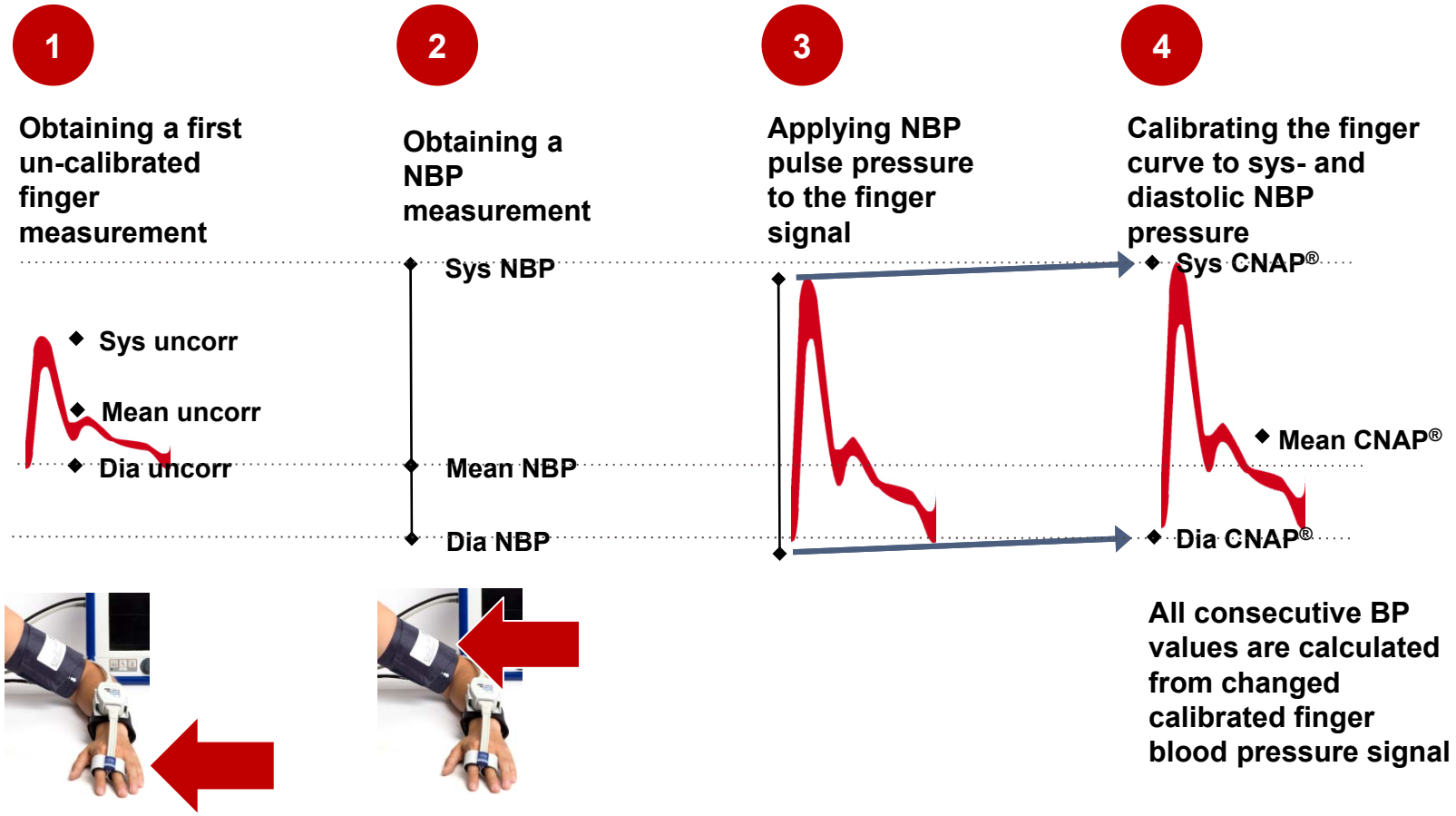
In- and deflating pressure chambers following the blood pulsation

[1] Jan Penaz, Brno, Czech Republic 1973

[2] Fortin J et al.: Continuous non-invasive blood pressure monitoring using concentrically interlocking control loops. Comput in Biol Med 36 (2006) 941 – 957

Interaction of fingersensor with NBP provides high accuracy BP signal – equivalent to invasive arterial line

CALIBRATION TO CLINICAL GOLD STANDARD



Cardiac output measure obtained from accurate blood pressure waveform using well-known pulse contour analysis

CNAP® HEMODYNAMICS

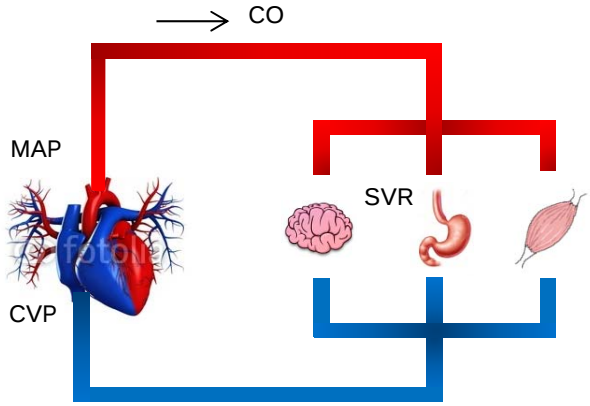
- Applying Ohm's Law to Hemodynamics

Voltage = Current x Resistance

MAP - CVP = CO x SVR

MAP ≈ CO x SVR

MAP … mean arterial pressure
CVP … central venous pressure*
CO … cardiac output
SVR … systemic vascular resistance



MAP	derived from accurate blood pressure waveform provided by Vascular unloading
CO	is calculated from pulse contour analysis (PCA)
SVR	results from CO and MAP
SVI, CI, SVRI	absolute values can be indexed to body surface area

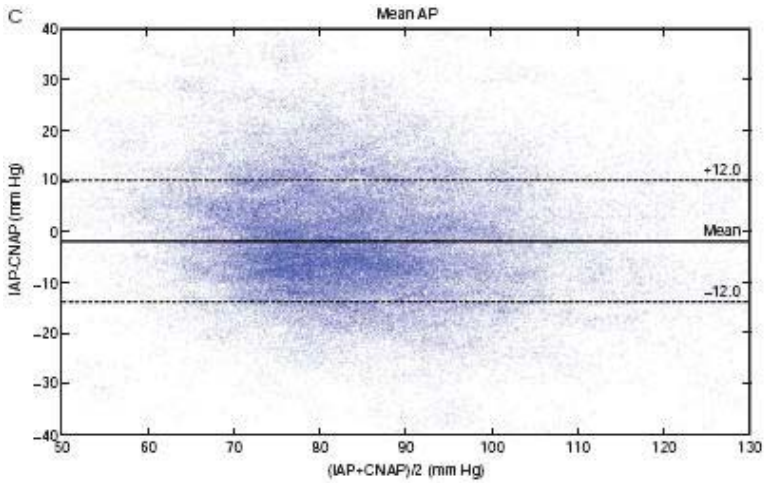
* CVP ≈ 7 [mmHg] and can be neglected

BIOPAC® Systems, Inc.
WWW.BIOPAC.COM

CNAP® arterial pressure is comparable with an invasive arterial line, even during general anesthesia

CLINICAL VALIDATION: CNAP® BLOOD PRESSURE

Erlangen, Germany[1]:



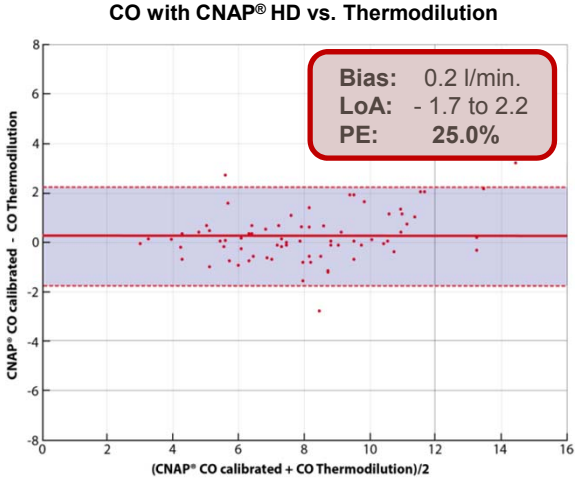
- 88 Patients (Neuro, Abdominal, Cardiac Surgery)
- Bland-Altman Plot for MAP:
  - **Bias (SD) = -1.6 (11.0) mmHg**
- **Precision (trending)**:
  - CNAP® as accurate as invasive BP (3,2 mmHg for MAP)
- 82.1% fast blood pressure changes *detected simultaneously* by CNAP® and IBP

[1] Jeleazcov et al. Precision and accuracy of a new device (CNAP) for continuous non-invasive arterial blood pressure monitoring: assessment during general anesthesia. British Journal of Anesthesia 2010 vol. 105 (3) pp. 264-72

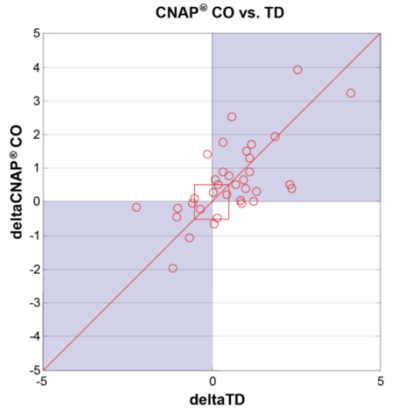
CO with CNAP® HD is inter-changeable with clinical standards and tracks changes reliably

CLINICAL VALIDATION: CARDIAC OUTPUT WITH CNAP® HD

- ***HIGH ACCURACY*** of non-invasive CO with CNAP® HD compared to invasive transpulmonary thermodilution[1]. Bland-Altman plots show:
  - Small bias (0.2 l/min) and narrow limits of agreement (LoA: -1.7 to 2.2)
  - Percentage error: 25% (according to strict Critchley standard of ≤ 30% [2,3])



- ***HIGH TRENDING ABILITY*** of non-invasive CO with CNAP® HD compared to invasive clinical standards
  - Concordance rates ≥ 90%[4] (according to standard[5])



[1] Wagner, J. Y., Grond, J., Fortin, J., Negulescu, I., Schöfthaler, M., & Saugel, B. (2015). Continuous noninvasive cardiac output determination using the CNAP system: evaluation of a cardiac output algorithm for the analysis of volume clamp method-derived pulse contour. *Journal of Clinical Monitoring and Computing*. doi:10.1007/s10877-015-9744-1

[2] Critchley, L. A., & Critchley, J. A. (1999). A meta-analysis of studies using bias and precision statistics to compare cardiac output measurement techniques. *Journal of clinical monitoring and computing, 15(2), 85–91*

[3] Peyton PJ, Chong SW: Minimally invasive measurement of cardiac output during surgery and critical care. Anesthesiology 2010; 113:1220-35.

[4] CNAP® HD validation data for CE mark and prepared for publication in peer-reviewed journal – data available upon request

[5] Critchley LA, Lee A, Ho AMH: A critical review of the ability of continuous cardiac output monitors to measure trends in cardiac output. Anesth Analg 2010; 111:1180-92.

CNAP® is used in a variety of applications & scientific studies

RESEARCH EXAMPLES WITH CNAP®

BIOPAC Customers

Psychophysiology: Challenge & Threat
Cornick, Blascovich et al. from the University of California in Santa Barbara investigated the cardiovascular consequences of exercise in obese subjects in a stressful environment. Cardiovascular and self-report measures were recorded. Findings indicated that those who are more self-aware showed cardiovascular response patterns indicative of threat.[1]

Psychophysiology: Emotional Response
At Pitzer College, California, Noble et al. performed a study to assess the effects of mainstream media on women's physiological and psychological functioning.[2]

The Naval Aerospace Medical Research Laboratory studied the **detection of deception** by use of continuous blood pressure[3].

Sanchez-Gonzalez et al. evaluated the cardiovascular reactivity to anxiety in young and middle-aged individuals[4].

Psychophysiology: Interaction Hemodynamics & Brain
The Institute for Knowledge Discovery from Graz, Austria studied the influence of slow blood pressure oscillations on self-paced movements. "Free will" is not only brain directed but also a matter of blood pressure.[5]

[1] Cornick, J. E., & Blascovich, J. (2015). Consequences of objective self-awareness during exercise. Health Psychology Open, 2(2), 2055102915598088. doi:10.1177/2055102915598088

[2] Noble, M. L. (2012). The Effect of Mainstream Media on Body Image and Stress Reactivity in Latina Females. *Pitzer SeniorTheses*.

[3] Taylor, M. K., Horning, D. S., Chandler, J. F., Phillips, J. B., Khosravi, J. Y., Bennett, J. E., … Gao, H. (2011). A Comparison of Approaches To Detect Deception. *Technical Report, Naval Aerospace Medical Research Laboratory*, (11).

[4] Sanchez-Gonzalez, M. A., Guzik, P., May, R. W., Koutnik, A. P., Hughes, R., Muniz, S., … Fincham, F. D. (2015). Trait anxiety mimics age-related cardiovascular autonomic modulation in young adults. Journal of Human Hypertension, 29(4), 274–80. doi:10.1038/jhh.2014.72

[5] Pfurtscheller, G., Ortner, R., Bauernfeind, G., Linortner, P., & Neuper, C. (2010). Does conscious intention to perform a motor act depend on slow cardiovascular rhythms? *Neuroscience Letters*, *468*(1), 46–50

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RESEARCH EXAMPLES WITH CNAP®

BIOPAC Customers

Physiology
Hurr et al. from the Department of Kinesiology and Health Education (The University of Texas at Austin; USA) determined whether there is a difference in cerebral vasodilatory capacity in response to rebreathing-induced hypercapnia between African Americans and Caucasian Americans.[6]

Sports
Telles et al. assessed heart rate variability, non-invasive arterial BP, and respiration rate, during alternate nostril yoga breathing and breath awareness sessions.[7]

Gerontology
Pereira et al. from Marquette University, USA, investigated the steadiness of muscle contractions in young and old adults during high and low cognitive demand tasks.[8]

Contact us for a complete bibliography of CNAP® / NIBP100D studies

[6] Hurr, C., Kim, K., Harrison, M. L., & Brothers, R. M. (2015). Attenuated cerebral vasodilatory capacity in response to hypercapnia in college-aged African Americans. Experimental Physiology, 100(1), 35–43. doi:10.1113/expphysiol.2014.082362
[7] Telles, S., Sharma, S. K., & Balkrishna, A. (2014). Blood Pressure and Heart Rate Variability during Yoga-Based Alternate Nostril Breathing Practice and Breath Awareness. Medical Science Monitor Basic Research, 20, 184–93. doi:10.12659/MSMBR.892063
[8] Pereira, H. M., Spears, V. C., Schlinder-Delap, B., Yoon, T., Nielson, K. A., & Hunter, S. K. (2015). Age and sex differences in steadiness of elbow flexor muscles with imposed cognitive demand. European Journal of Applied Physiology, 115(6), 1367–79. doi:10.1007/s00421-015-3113-0