

Cuffless Blood Pressure Monitoring: CSEM's catalog of applications

J. Solà, M. Proença, F. Braun, A. Vybornova, C. Verjus, J.-M. Koller, A. Moreira De Sousa, M. Bertschi

The quest for sensors that can provide accurate beat-to-beat blood pressure measurements without inflating pneumatic cuffs has started around the globe. For more than 10 years, CSEM has been a pioneer in the development, implementation, and validation of novel solutions based on either pulse wave velocity or pulse wave analysis principles. CSEM's blood pressure technologies open the door to a catalogue of disruptive applications ranging from new paradigms in routine blood pressure measurement in the operating room to the first ever cuffless monitors for wearable 24/7 applications. Clinical validations of CSEM's technologies are ongoing in different Swiss university hospitals.

CSEM's strategy in the measurement of blood pressure (BP) is based on two measurement principles, depending on the targeted BP application (see Table 1):

a) Pulse wave velocity (PWV) principle: estimates of BP are obtained from measurements of the transit time of arterial pulses travelling from the ascending aorta towards the vasculature of the upper-thoracic skin;^[1]

b) Pulse wave analysis (PWA) principle: estimates of BP are obtained via a CSEM-proprietary analysis of arterial pulsatility patterns at body locations such as the wrist or the fingertip.^[2]

While both principles require a user-dependent calibration manoeuvre to provide absolute BP estimates, calibration-free estimates have been shown to provide an accurate indication of the BP trend over time, which is sufficient for most clinical scenarios.

Based on these principles, the results obtained from different ongoing clinical studies in Swiss university hospitals prove the feasibility of a catalogue of disruptive BP applications (Table 1).

Table 1: CSEM catalogue of cuffless BP applications.

BP application	CSEM cuffless solution
Continuous ambulatory BP monitoring 24/7	PWV measurements at the chest via CSEM's cooperative sensor technology (combined ECG, bioimpedance, and PPG sensors) ^[3]
Continuous BP trend monitoring during anaesthesia	PWA measurements at the fingertip via re-analysis of transmission PPG signals from routinely used PulseOx sensors. ^[4]
Continuous ambulatory BP monitoring during sleep	PWA measurements at the wrist via reflective PPG sensors integrated in a wrist watch device. ^[5]
Spot ambulatory BP monitoring	PWA measurements at the wrist via reflective PPG sensors integrated in a watch device.
Spot ambulatory BP monitoring	PWA measurements at the fingertip via reflective optical measurements from a smartphone camera.

Preliminary results of an ongoing clinical study (NCT02651558) at CHUV, Lausanne University Hospital, are illustrated in Figure 1. Ground-truth values of systolic, diastolic, and mean BP are obtained from an arterial line inserted at the radial artery. In this example, PWV measurements at the chest provide estimates of mean BP, and PWA measurements at the fingertip provide estimates of systolic BP.

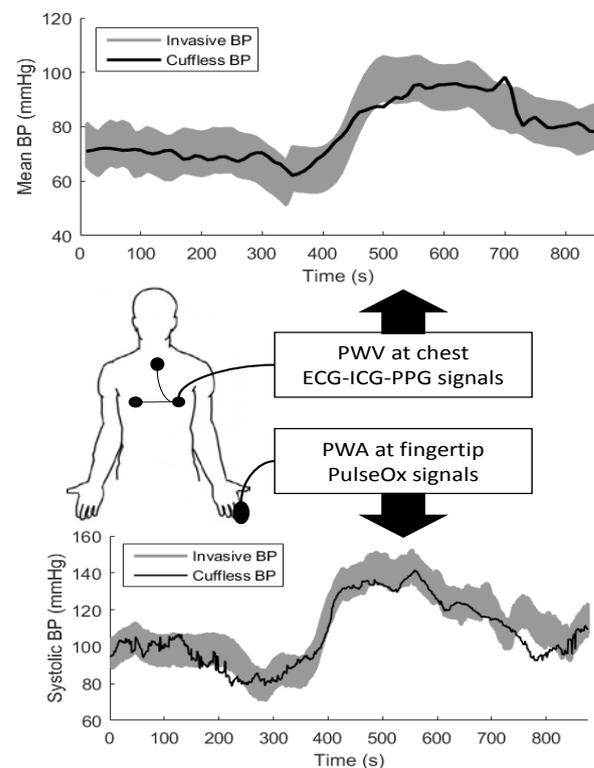


Figure 1: Example of good performance of CSEM cuffless technologies to estimate: a) mean BP via a chest sensor (upper panel), and b) systolic BP via a PulseOx sensor (lower panel), when compared to arterial line measurements on an anesthetized patient. Grey regions in plots depict reference BP ± 8 mmHg.

While CSEM technologies for cuffless BP are drawing the interest of numerous key players in the medical and wearable market, licensing of the dedicated patent portfolio for particular use cases is available upon request.

[1] J. Solà, Continuous non-invasive blood pressure estimation, ETHZ PhD dissertation No. 20093, Dr. Sc., 30 November 2011.
 [2] M. Proença, et al., Method, apparatus and computer program for determining a blood pressure value, WO2016138965.
 [3] J. Solà, et al., Non-invasive and non-occlusive blood pressure estimation via a chest sensor, IEEE TBME, 60(12), 2013.

[4] J. Solà, et al., Continuous non-invasive monitoring of blood pressure in the operating room: a cuffless optical technology at the fingertip, Proc. BMT2016, Basel, 2016.
 [5] J. Solà, et al., Cuffless blood pressure monitoring: experimental evidences of a beat-to-beat PPG technique, Proc. EMBC2016, Orlando.