A Chest Sensor for Continuous Measurement of Blood Pressure and Arterial Stiffness

J. M. Solà i Carós, O. Chételat

The technology allowing the continuous non-invasive measurement of blood pressure is attracting multiple players in the medical industry. The demand is a consequence of the aging of the population which requires new devices to assess cardiovascular health status at home. Today blood pressure is measured by an inflation cuff placed either round the upper arm or the wrist. Patients complain that inflation cuffs are too occlusive and cumbersome, while clinicians allege cuff measurements to be intermittent. Based on CSEM proprietary technology for the ambulatory monitoring of physiological parameters, a chest sensor is presented capable of providing continuous measurements of blood pressure and arterial stiffness.

During the past few years a promising family of techniques based on the so-called Pulse Wave Velocity (PWV) principle [1] has been explored to estimate Blood Pressure (BP) non-invasively and continuously.

In brief, these techniques rely on the existing relationship between BP and the velocity of propagation of pressure pulses through the arterial tree (in m/s): by applying a subject-dependent calibration procedure one is able to provide BP estimates from PWV measurements.

Because several solutions have been proposed to measure PWV beat by beat in humans [1], this approach has gained widespread popularity.

Unfortunately, every unsupervised existing technique to assess PWV relies on the measurement of pressure pulses at distal arteries [1] (arteries located far away from the heart). Being affected by local phenomena such as vasomotion and changes in hydrostatic pressure, PWV at these peripheral sites is not a good representative of central BP.

CSEM presents a novel sensor capable of measuring pulse pressure propagation velocities within central arteries in a fully non-invasive, non-occlusive and unsupervised manner.

Being fully integrated in a wearable chest belt, the sensor provides continuous estimates of PWV and BP by applying multi-parametric processing techniques to the signals obtained from electrical and optical embedded sensors (Figure 1).

- A phono-cardiogram (PCG) and an impedance cardiogram (ICG) are combined to detect the opening of the aortic valve, producing a pre-ejection period (PEP) value.
- A multi-channel photo plethysmograph (PPG) provides an estimation [2] of the arrival time (PAT) of the pressure pulse at the capillary bed at the sternum
- The pulse transit time (PTT) from the aortic valve to the chest is computed by subtracting PEP from PAT. PTT is a transit time value normally ranging between 10 and 30 m/s.
- A pulse wave velocity value (PWV) is obtained by normalizing PTT by morphological measurements performed on the user's body. PWV is a pulse wave propagation velocity value normally ranging between 6 and 16 m/s.
- A blood pressure value (BP) is obtained by applying a subject-dependent calibration to the PTT value. Mean blood pressure values normally range between 70 and 120 mmHg.

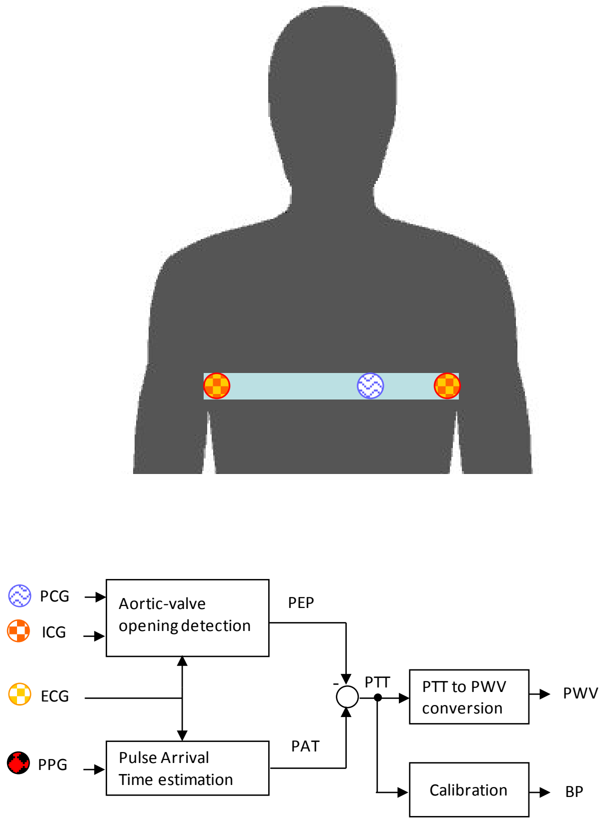

Figure 1: Description of the chest sensor for the measurement of blood pressure (BP) and pulse wave velocity (PWV)

The accuracy of the chest sensor in measuring central PWV was assessed in collaboration with the Swiss Cardiovascular Center in Bern.

The goal of this study was to determine whether PWV values as provided by the chest sensor (chest PWV) did correlate with the standard clinical measurement of arterial stiffness, the so-called carotid-to-femoral PWV. Note that since 2007, the European Society of Hypertension (ESH) has recommended the measurement of such parameter in its guidelines for the evaluation of cardiovascular risk.

A prospective validation study [3] was thus designed involving *n*=29 normo- and hypertensive male subjects (age: 26…72 years). Reference PWV values were obtained from supervised PWV measurements performed at the carotid and femoral arteries (COMPLIOR, Alam Medical, France).

The study demonstrated Chest PWV to correlate with Carotid-to-Femoral PWV (*r*= 0.88), as shown in Figure 2.