Clinical evaluation of a multiwavelength pulse oximeter

The two wavelengths design of the majority of pulse oximeters assumes only two absorbing hemoglobin fractions, oxyhemoglobin (O_2Hb), and reduced hemoglobin (HHb) irrespective of the presence of methemoglobin (MetHb) and carboxyhemoglobin (COHb). If MetHb or COHb is present, it contributes to the pulse-added absorbance signal and will be interpreted as either HHb or O2Hb or some combination of the two.

A noninvasive multiwavelength pulse oximeter was developed measuring O2Hb, HHb, MetHb, and COHb at a specified accuracy of 1.0%. The system (Fig. 1) was designed with respect to the results of numerical simulations [1]. It con-sists of 9 laserdiodes (LDs) and 7 light emitting diodes (LEDs), a 16-Bit analog-digital converter (ADC) and has a sampling rate of 16 kHz. The laser diodes and LEDs were coupled into multimode fibers and led to the finger clip and then the photodiode by a liquid lightguide.

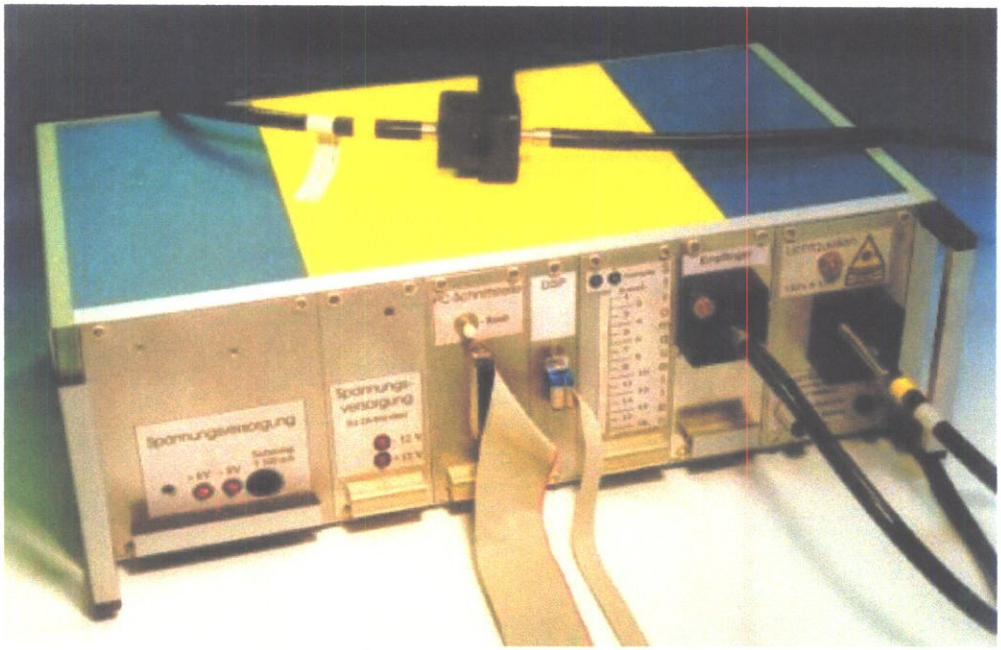

Fig. 1: Setup of the multiwavelength pulse oximeter

As for clinical evaluation, patient data from the multi-wavelength pulse oximeter, from a setup with a quartz tungsten halogen lamp (with fiber output) and a diode array spectrometer, from two standard pulse oximeters and three in-vitro oximeters (Radiometer OSM3, Radiometer ABL 520 and AVL 912 CO-Oximeter) used as references, were recorded simultaneously using a single PC.

The data sets (approx. 60 MByte per measure-ment) are now undergoing extensive evaluations by applying different approaches, e.g. analytical algorithms as non-negative least squares (NN-LSQ) or empirical algorithms using neural networks.

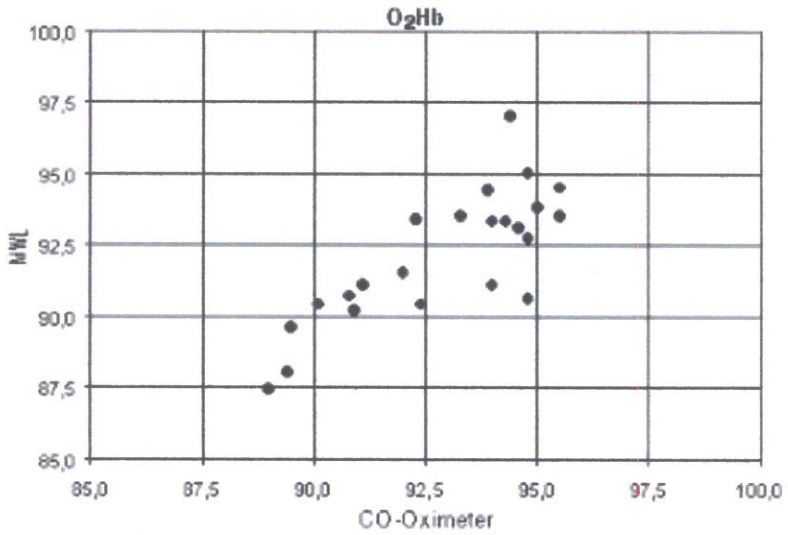

Fig. 2: Reference vs. MWL - O_2Hb concentration

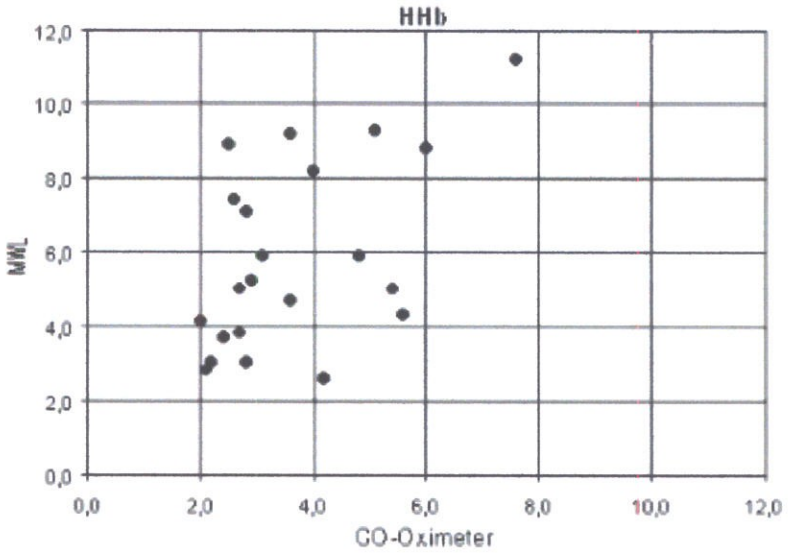

Fig. 3: Reference vs. MWL - HHb concentration

The first results (Fig. 2 and 3) using the NN-LSQ algorithm indicate that one could expect to noninvasively monitor the concentrations of oxyhemoglobin (O_2Hb), reduced hemoglobin (HHb), methemoglobin (MetHb), and carboxyhemoglobin (COHb) at an accuracy of about 1 %. Additionally scattering effects in tissue have to be taken into account with respect to the algo-rithms to be implemented. This can be realized by integrating a wave-length dependent differential pathlength factor into the Lambert-Beer law.

References

1. N. Lutter, K. Engelhardt, B. Manzke, K. Zürl, W. Stork: "Computer simulation of a multi-wavelength pulse oximeter", ZAK, Wien, September 1995
2. B. Manzke, J. Schwider, N. Lutter, K. Engelhardt, W. Stork: "Multi wavelength pulse oximetry in the measurement of hemoglobin fractions", Proc. SPIE, Vol. 2676, pp. 332-340, San Jose,