Reflective Pulse Oximetry for Neonates Monitoring

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Arterial oxygen saturation is one of the key parameters routinely monitored using pulse oximetry (SpO_2) in neonatal intensive care units. However, available SpO_2 probes for neonates are all based on transmission *photoplethysmography (PPG) requiring the light to go through the perfused tissue and limiting the placement of the sensors to the limbs. To overcome the limitation of currently-used transmission probes, a novel design based on multichannel reflective pulse oximetry is presented which also integrates electrodes for ECG and respiration monitoring.*

For preterm infants and severely ill newborns undergoing intensive or intermediate care, it is crucial to monitor their vital signs, in particular their cardiorespiratory system. Heart and respiratory rate are routinely monitored by electrocardiography (ECG) and impedance plethysmography (IPG) to assess correct breathing and cardiac activity.

Additionally for more than 40 years, pulse oximetry (SpO_2) used to monitor the amount of oxygen in blood and is even referred to the fifth vital sign. However, most current SpO_2 probes for neonates are based on transmission photoplethysmography (PPG) which requires an additional sensor and limits the placement of it to the arms and legs of the neonate (Figure 1). Unfortunately, such a sensor position has several limitations. Firstly, newborns continuously move their limbs leading to movement artefacts and thus false alarms. Furthermore, the hands, forearms, feet and lower legs are preferred sites for insertion of peripheral and central catheters.

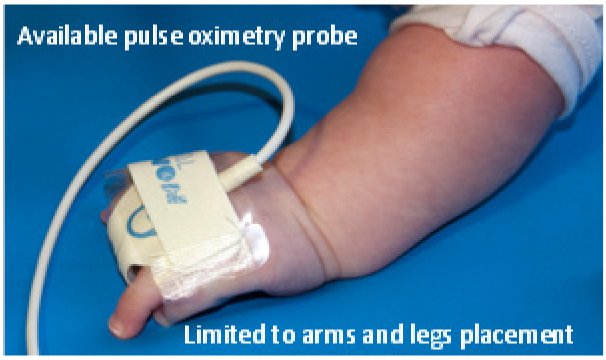

Figure 1: Illustration of commercial pulse oximetry probe

To overcome the limitation of currently-used SpO_2 probes, with the herein presented research, CSEM has investigated the concept of an innovative SpO_2 design based on reflective PPG (Figure 2). The new design is composed of two sensors allowing the monitoring of the following vital signs:

Physiological parameter	Technology
Heart rate	ECG
Respiratory rate	IPG
SpO_2	Reflective PPG

The use of transmission PPG theoretically enables the positioning of the sensor anywhere on the body. In addition to the potential new locations, the integration of ECG and respiration monitoring to the SpO_2 probe, will lead to highly integrated miniaturized multi-parameter probe freeing space on the neonate body and reducing considerably the number of connected cables.

To limit motion artefacts and free neonates limbs for catheter insertions, the SpO_2 sensor is placed on the trunk, which can hardly be moved by neonates.

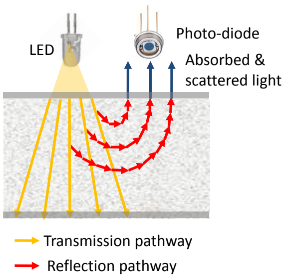

Figure 2: Photoplethysmography technology illustration

To alleviate potential issues with lower signal to noise ratio due to the reflective PPG and to anticipate the heterogeneity of the blood irrigation on the thorax, a multichannel reflective PPG and an accelerometer are implemented (Figure 3). The multi-channel approach combined with an innovative algorithm that takes into account ECG and accelerometer will bring the reliability of the SpO_2 measurement to a level comparable of classical SpO_2 probes. This novel design is expected to improve the quality of neonatal physiological monitoring, and to decrease the workload of NICU care givers by for example reducing the amount of false alarms.

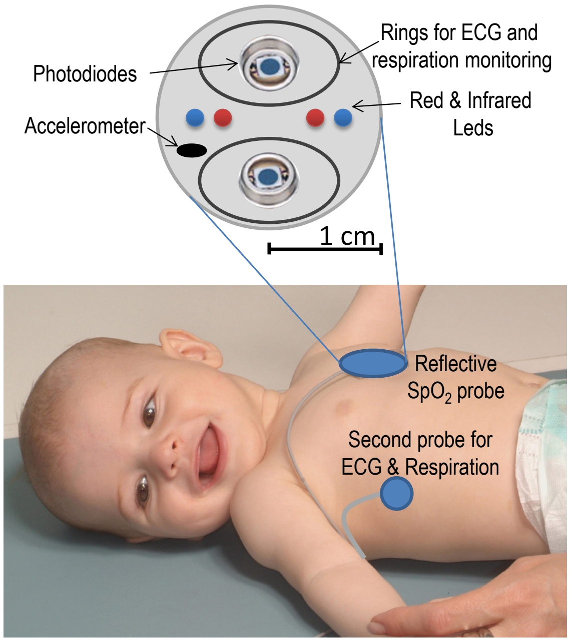

Figure 3: Multiparameter probe design for neonate monitoring

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