An electrical impedance based neonatal respiration monitor for pneumonia detection

Shahnaj Parvin, Ahamad Intiaz Khan, Kamrul Hussain, M Abdul Kadir and K Siddique-e Rabbani
Department of Biomedical Physics & Technology, Dhaka University, Dhaka, Bangladesh. Email: rabbani@univdhaka.edu

Abstract
There is no good detection technique for pneumonia as yet, particularly for neonates and babies in low resource countries where qualified doctors are not available. X-ray, normally used in conjunction with other symptoms, is not available either. Respiration rate in conjunction with other symptoms can give a diagnosis, and electronic equipment interface is needed for a telemedicine system, but a baby cries on connecting diagnostic equipment, which changes the respiration rate jeopardising the measurement. We developed an electrical impedance based technique using an innovative palm-worn electrode probe mounted on a flexible rubber pad and covered by a cotton sheet, to be worn by the mother or a nurse, using a Velcro strap. Necessary electronic circuitry, computer interface and software were also developed. As the mother touches the baby’s thorax using this palm-worn electrode pad the impedance variation of lungs with respiration is displayed and recorded in a computer. Later, using signal processing techniques the respiration rate is obtained from acquired data. Pulsating blood flow also creates changes in the data and heart beat rates may also be extracted from the same measurement. Four electrode impedance measurement technique was employed where current is passed through two electrodes and the potential is measured between the other two. Measurement on a 2 year child and a 2 month old baby were successful – they did not cry.

Methods and Materials

- Tetra-polar Electrical Impedance Measurement (TPIM) placing 4 electrode as shown. Constant current at 10kHz (~ 1mA) applied across a pair of adjacent electrodes. Potential measured across opposite pair of electrodes.
- Measurement from outside skin, Non-invasive
- Contact impedance eliminated in TPIM.
- Impedance of the central region around the 4 electrodes contributes more to measurement. Depth sensitivity gives lung information.
- Change of Localised transfer impedance between inspiration and expiration indicates ventilation of the lungs and indirectly indicates presence of any mass (if the change is less than normal for the particular location)
- If the measurement system can be made with very low noise, it may be possible to detect heart rate through pulsating blood flow in the arterioles and capillaries under the skin, as the electrical impedance changes with the amount of blood underneath.

Electrodes and measurement
- Flexible rubber pad with Velcro band. Metallic electrodes (Nickel coated Cu in the prototype, to be replaced by stainless steel).
- To make the pad comfortable to touch, covered with a cotton fabric with thick cotton buttons sewed at the location of the electrodes. The buttons were soaked with drops of saline for conduction.
- The mother or a nurse wears the electrode in the palm and either holds the baby touching the backside of the thorax with the electrodes, or places the hand with the electrodes on the chest of a lying baby or a sitting child.

Results & Observations
Raw plot of lungs ventilation measured on a 2 month old baby just recovered from pneumonia is shown below. Lower figure gives the FFT showing a peak at 0.6 Hz which is the one from respiration. This corresponds to a rate of 36 per minute.

Discussion and Conclusion
- The main challenge of the present work was to measure the respiration rate without upsetting the babies and we have achieved this objective successfully.
- The measured Respiration Rate (RR) together with temperature and chest movement can be used as diagnostic tool for screening pneumonia in children.
- For rural areas where medical doctors are not available, the measured data can be transferred real time through telediagnosis to a doctor.
- The same system with small modifications may be used to study localised lung ventilation indicating presence of any masses in the lung.

References