Evaluation of Ultrasound-Based Sensor to Monitor Respiratory and Nonrespiratory Movement and Timing in Infants

Goal: To describe and validate a noncontacting sensor that used reflected ultrasound to separately monitor respiratory, nonrespiratory, and caretaker movements of infants. Methods: An in-phase and quadrature (I & Q) detection scheme provided adequate bandwidth, in conjunction with postdetection filtering, to separate the three types of movement. The respiratory output was validated by comparing it to the electrical activity of the diaphragm (Edi) obtained from an infant ventilator in 11 infants. The nonrespiratory movement output was compared to movement detected by miniature accelerometers attached to the wrists, ankles, and heads of seven additional infants. Caretaker movement was compared to visual observations annotated in the recordings. Results: The respiratory rate determined by the sensor was equivalent to that from the Edi signal. The sensor could detect the onset of inspiration significantly earlier than the Edi signal (23+/−69 ms). Nonrespiratory movement was identified with an agreement of 0.9 with the accelerometers. It potentially interfered with the respiratory output an average of 4.7+/−4.5% and 14.9+/15% of the time in infants not requiring or on ventilatory support, respectively. Caretaker movements were identified with 98% sensitivity and specificity. The sensor outputs were independent of body coverings or position. Conclusion: This single, noncontacting sensor can independently quantify these three types of movement. Significance: It is feasible to use the sensor as trigger for synchronizing mechanical ventilators to spontaneous breathing, to quantify overall movement, to determine sleep state, to detect seizures, and to document the amount and effects of caretaker activity in infants.