Model-Based Analysis of Apnea-Bradycardias in Newborns

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Context: Recurrent episodes of apnea, bradycardia and severe intermittent hypoxia are observed in 10% to 85% of preterm infants, depending on their gestational age and are mainly related with cardiorespiratory immaturity. They are associated with major risks during the first weeks of life. The creation, validation and analysis of appropriate mathematical models of preterm cardiorespiratory physiology can be useful to improve the interpretability of clinical data acquired in neonatal intensive care units (NICU).

Methods: Cardiorespiratory data consisting of a continuous 12 hours recording of transthoracic impedance and ECG signals were acquired from 18 preterm newborns with gestational age of 24-30 weeks and birth weight of 620-1595 g, around their 7th day of life.

The proposed model of cardiorespiratory interactions integrates: i) the respiratory system, ii) the cardiovascular system, iii) the gas exchange (in the lungs and the metabolism) and iv) the neural control. The model was adapted to preterm newborn physiology with a gestational age of 28 weeks, post-menstrual age of 29 weeks and weight of 1 kg. Mixed apnea with and without bradycardia were simulated by modifying functional residual capacity and simulations were compared with clinical data.

Results and Discussion: 106 isolated apnea events (> 10 sec) were manually annotated from the database, including 19 apneas with bradycardia (around 53%). A first qualitative comparison has shown a close match between experimental and simulated heart rate series during apnea with bradycardia (RMSE 20.66 bpm) and without (RMSE 3.89 bpm).

Conclusion: To our knowledge, **t**his work represents the first integrated representation of the cardiorespiratory interactions during apnea-bradycardia, adapted to the preterm newborn physiology. Further work, will focus on the model validation through patient-specific identifications of model parameters in order to reproduce clinical data observed in NICU.

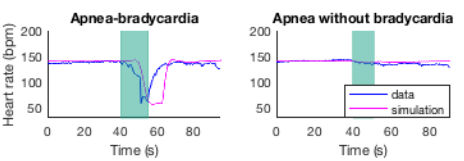

Figure 1: Heart rate comparison during apnea with and without bradycardia, between experimental data and simulation.