Using nonlinear data analysis and data mining to assess physiological changes in preterm infants measured with near-infrared spectroscopy, pulse oximetry and electrocardiography

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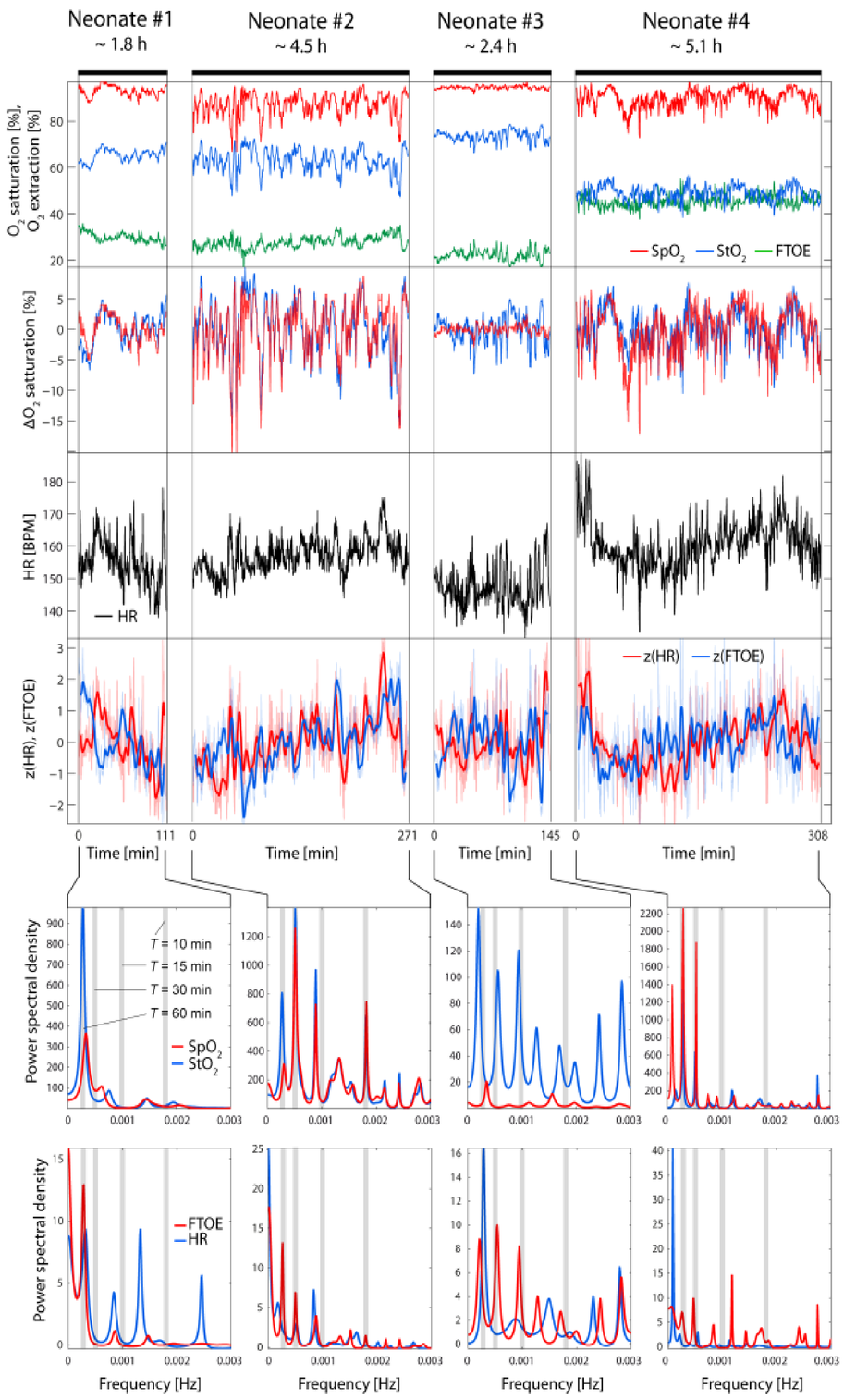
Preterm infants have an underdeveloped regulation system for respiration as well as systemic (StO_2) and cerebral (StO_2) blood circulation. This increases the occurrence of pathophysiological processes in cerebral hemodynamics (i.e. hypoxic, hyperoxic episodes). Aim of the study: (i) long-term measurements of StO_2, SpO_2; (ii) application of a new analysis framework to access the regulatory state of the hemodynamic systems.



Material and Methods

- Total study population: n = 20 (gestational age [GA] at birth: 29.9 ± 2.3 weeks). Analyzed preterm infants in this study: n = 4.
- Parameters: StO_2, SpO_2, FTOE (fractional tissue oxygen extraction), HR (heart rate). StO_2: via near-infrared spectroscopy (NIRS).
- Analysis:
  - (i) phase-space modeling & recurrence quantification analysis (RQA),
  - (ii) maximum entropy spectral analysis (MESA),
  - (iii) nonparametric nonlinear regression based on the alternating conditional expectation (ACE) algorithm,
  - (iv) the maximal information-based nonparametric exploration (MINE) technique.
- Additional parameters: variability index 1 and 2 (VI_1, VI_2)

Results, Discussion & Conclusions

- Subject-specific signal dynamics.
- Inverse correlation between StO_2 and Htc.
- Neonate #3: large *VRI*, low StO_2/SpO_2 correlation (r_{ACE}, *MIC*), difference in frequency spectra → ductus arteriosus.
- Oscillations with $T \approx 60$ and 30 min.
- Neonates with the lowest GA (#2, #4): largest variability of StO_2, SpO_2 and FTOE.
- Novel framework: premising tool to access the systemic and cerebral regulatory state based only on StO_2, SpO_2 and HR measurements.

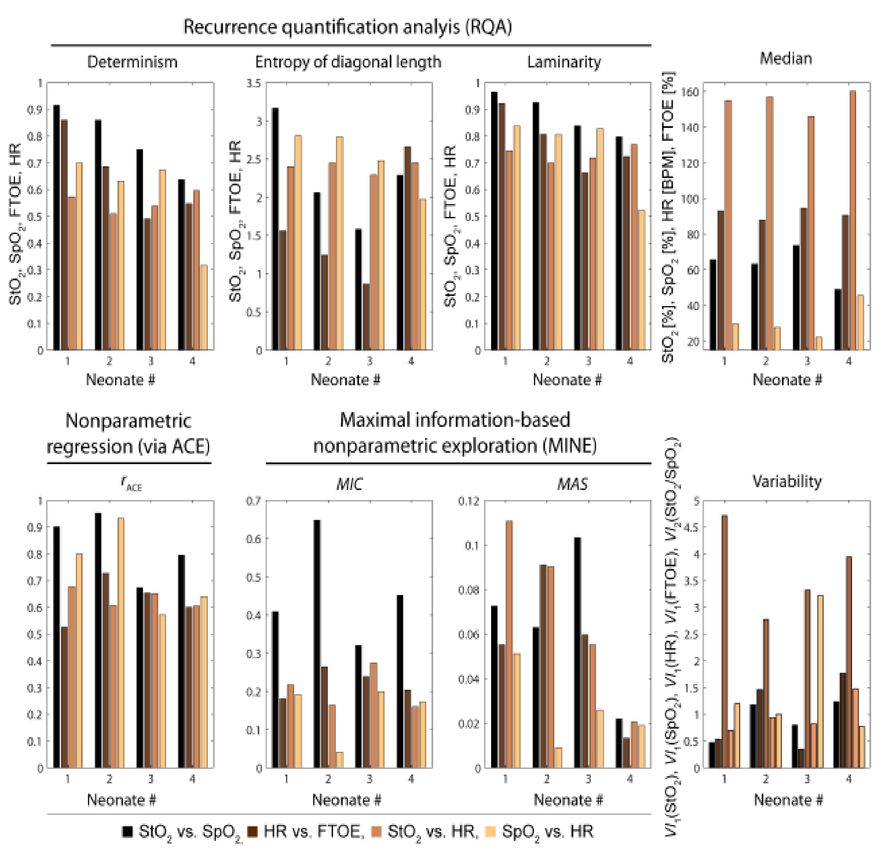


Fig. 1: Visualization of the analyzed signals, frequency spectra and numerical values obtained by RQA, ACE and MINE.