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Utilising entropy analysis as a method to assess fetal wellbeing by extracting cardiotocography signals

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Rationale: Electronic fetal monitoring (EFM) or cardiotocograph (CTG) is a technical recording of the fetal heart rate (FHR) and uterine contractions (UC), undertaken during pregnancy or labour to assess fetal wellbeing. Most of the research relating to EFM has focused on FHR and/or the affect of UC on FHR.

Aim: The aim of the study was the correlation of FHR with UC and fetal movements (FM), based on in depth analysis of anonymous retrospective antenatal CTGs, undertaken between 34-42 weeks of gestation.

Methods: 23 signals fulfilling the inclusion criteria were collected. The length of the signals ranged from 30 minutes to 4 hours. The non-linear dynamic single signal analysis included the mutual information, permutation entropy and Kernel density. For the multiple signals' analysis, the conditional, cross-approximate and cross sample entropy algorithms were used. To assess the linear correlation Pearson correlation coefficient were used.

Results/Conclusion: All signals analysed as pairs (FHR-UC, FHR-FM, UC-FM). Mutual information, permutation entropy and cross approximate entropy algorithms showed statistically significant sequence similarity for FHR-UC. Further segmentation of the signals in 3-10 segments were performed confirming the statistical significance of the results. Important results were obtained from the analysis of the FMs, despite the processing difficulties. The results of this study reinforce the importance of FMs as a method for the assessment of fetal wellbeing.

Implications of findings: This pilot study is the beginning of a series of research projects aimed to offer better understanding of fetal health parameters and following improving maternal and fetal wellbeing.

Key words: Electronic fetal monitoring, signal processing, fetal movements