Early assessment of fetal well-being by means of nonlinear parameters (STV, ApEn and SampEn): a fMCG study on normal pregnancies

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Background and aim of the study

Fetal well being should be monitored to prevent fetal death or hypoxia. Fetal heart rate variability (fHRV), which is generally reduced in distressed fetuses, is monitored by cardiotocography (CTG), or, alternatively, by fetal electrocardiography (fECG) or fetal magnetocardiography (fMCG) [1].

CTG has low temporal resolution, which affects fHRV estimates, and fECG produces noisy signals that are available only from 24 to 34 gestational weeks. Conversely, fMCG provides fetal signals with good temporal and spatial resolution during the entire second half of gestation.

Short Term Variability (STV) is used to assess fHRV on CTG signals, and shows a correlation between lower STV and fetal acidemia and death [2]. Differentiation between healthy and distressed fetuses can be also achieved by exploring signal entropy, estimated by Approximate Entropy (ApEn) or Sample Entropy (SampEn) [3].

It has been claimed that STV and entropy show high correlation in distressed fetuses [4]. Therefore, in this study we explore the correlation between STV and ApEn or SampEn in healthy fetuses.

Methods

Nineteen fMCG data sets of five minutes duration were collected for 11 volunteers (gestational age = 31.3 ± 2.7 weeks) with a 55 channel low-temperature dc-SQUID system (ATB Argos 200) installed at Itab (Chieti University, Italy).

The fetal cardiac signals were separated by Fast-ICA [5]. The RR interval series obtained from the fetal cardiac signals were analyzed against false or missing R peaks and used to calculate SampEn, ApEn and STV.

STV, which is a beat-to-beat measurement of HRV, was estimated on one minute fMCG recording as follows:

$$STV = \frac{1}{24} \sum_{i=1}^{24} (T_{i+1} - T_i)$$

where $T_i$ is the RR time interval in ms calculated every 2.5s (60s/24).

Correlation among SampEn, ApEn and STV was calculated using the Pearson correlation coefficient.

Results

Figure I shows the RR time interval series of two fetuses with high (a) and low (b) variability. The STV, ApEn and SampEn values are also given.

The mean and STD of the STV, and ApEn and SampEn values for all analyzed fetuses are shown in Table I.

Weak correlations were found between STV (3.1± 2.7ms) and ApEn (0.7± 0.2) (r=0.3), and between STV and SampEn (0.5± 0.2) (r=0.2).

As no risk pregnancies were analyzed, low STV values were explained with the occurrence of epochs of low fetal activity.

Our preliminary results suggest a potential role of entropy estimators such as ApEn and SampEn in the early detection of distressed fetuses and for their differentiation from healthy fetuses.

Further investigation may be done to assess the effectiveness of those estimators in risk pregnancies.

Conclusions

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References