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ORIGINAL PAPER / OBSTETRICS

Diagnosing antenatal fetal distress

Short title: Diagnosing fetal compromise

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ABSTRACT

Objectives: The values of acceleration capacity and deceleration capacity are known to capture fetal neurological development. The fetal growth restriction was found to be featured by decreased variables of phase rectified signal averaging. We have speculated that acceleration capacity and deceleration capacity could be of use in the detection of antenatal fetal distress during fetal growth restriction. The study was focused on the detection of the accuracy of acceleration capacity and deceleration capacity in diagnosing fetal distress.

Material and methods: In total, 124 pregnant women at 26–36 weeks of gestation were included in the study. The patients with appropriate to gestational age fetuses (n = 32) were enrolled in Group I. The patients with fetal growth restriction and an absence of fetal distress (n = 48) were observed in Group II. Lastly, the patients with fetal growth restriction and fetal distress (n = 44) were included in Group III. Fetal cardiosignals were obtained via non-invasive fetal electrocardiography. The maximally decreased acceleration capacity and deceleration capacity values were found in Group III.

Results: A correlation was found between umbilical artery resistance index and acceleration capacity and deceleration capacity variables in all study groups. We have found that the application of phase rectified signal averaging in the antenatal period showed high sensitivity and specificity in fetal distress detection.

Conclusions: Fetal acceleration capacity and deceleration capacity is a prospective option for the detection of fetal compromise during fetal growth restriction.

Key words: fetal growth restriction; fetal non-invasive electrocardiography; acceleration capacity and deceleration capacity; fetal distress

INTRODUCTION

Fetal neurological development and maturation change cardiovascular response to its intrauterine activity. The investigation of heart rate variability (HRV) provides a piece of objective information about fetal health. The variations of the cardiocycles duration are a “window” into fetal life. Fetal non-invasive electrocardiography is a challenging technique for the detection of fetal cardiosignals. The variables of fetal HRV are known to reflect its status [1].

The conventional biophysical marker of fetal well-being is the reactivity of fetal heart rate in the non-stress test (NST) [2]. The absence of the accelerations on the fetal heart rate tracing could be associated with fetal compromise or fetal “sleep”. Thus, NST is not specific in diagnosing fetal distress [3].

The values of phase rectified signal averaging are known to capture fetal neurological development. The fetal growth restriction (FGR) was found to be featured by decreased variables of acceleration capacity and deceleration capacity (AC/DC) [4–6]. FGR is known to be associated with an increased rate of fetal deterioration. We have speculated that AC/DC could be of use in the detection of antenatal fetal distress during FGR.

The study was focused on the detection of the accuracy of AC/DC in diagnosing fetal distress.

MATERIAL AND METHODS

In total, 124 pregnant women at 26–36 weeks of gestation were enrolled in the investigation. Only those who met the inclusion criteria and gave informed consent were included in the study (Tab. 1). The idiopathic FGR was detected by ultrasound. The population was divided into three groups. The patients with appropriate to gestational age fetuses ($n = 32$) were enrolled in Group I (control). The patients with FGR and an absence of fetal distress ($n = 48$) were observed in Group II. Lastly, the patients with FGR and fetal distress ($n = 44$) were included in Group III. Fetal cardiosignals were obtained via non-invasive fetal

electrocardiography (NI-FECG) from the maternal abdominal wall. The Cardiolab Babycard equipment (Ukraine) was used in this study. The diagnosis of fetal distress was performed via Doppler ultrasonography according to the abnormal umbilical and ductus venosus hemodynamic variables.

The results obtained were analyzed with the chi-square test to compare data between groups. For the assessment of the difference between non-parametric variables, the Mann-Whitney test was used. The significance was set at p -value < 0.05 . For the statistical analysis of the relationship between X and Y, the correlations coefficients were estimated with Spearman's test. SPSS for Windows Release 25.0 (SPSS Inc. Chicago, Illinois), the software was used for statistical analysis. The use of fetal HRV variables in diagnosing fetal distress was investigated. The sensitivity (Se) and specificity (Sp) of NST and AC/DC were calculated. The relative risk (RR) of NST and AC/DC in fetal compromise prediction were also checked.

RESULTS

The average values of maternal age, body mass index, and parity were not different in Group I, Group II, and Group III (Tab. 2). The observed Group II and Group III patients had a higher manifestation of gestational hypertensive disorders and early onset FGR.

The maximally decreased AC/DC values were found in Group III (Tab. 3). The variables of phase rectified signal averaging were lower in Group II than in Group I, but higher than in Group III. Thus, the gradual decline of AC/DC was found amongst all study groups.

The investigation of the possible coupling between the AC/DC and fetal umbilical artery resistance index (RI) values in the study population revealed certain regularity. A significant relationship was found in Group I ($R = 0.64$, $p < 0.05$). A similar correlation was detected in growth-retarded fetuses. The values of the Spearman correlation were almost equal in Group II and Group III (respectively, $R = 0.62$, $p < 0.05$; $R = 0.68$, $p < 0.05$). Therefore, AC/DC could be speculated as a marker for fetal deterioration. The detected correlation between AC/DC and umbilical blood pH in all study groups supported this thesis. The values of correlation coefficients ($R = 0.70$, $p < 0.05$; $R = 0.68$, $p < 0.05$; $R = 0.72$, $p < 0.05$ in Group I, Group II, and Group III, respectively) reflected the possible use of AC/DC in fetal monitoring.

The Se and Sp of nonreactive NST in diagnosing fetal distress were 65.22% (95% CI, 49.75%–78.65%) and 60.87% (95% CI, 45.37%–74.91%). The Se and Sp of the reduced AC/DC were 97.73% (95% CI, 87.98%–99.94%) and 95.83% (95% CI, 85.75%–99.49%). The

RR for fetal during FGR in the case of nonreactive NST was 0.59 (95% CI, 0.38–0.90; $p = 0.02$). The same RR in the case of the reduced AC/DC was 0.04 (95% CI, 0.01–0.16; $p < 0.001$).

DISCUSSION

Fetal electronic monitoring is known to have some serious restrictions in diagnosing fetal compromise. Only bradycardia is an evident sign of fetal deterioration [2, 3]. Several techniques were proposed for early detection of fetal distress. Our work has supported the opinion about the prospect of NI-FECG in fetal status detection [7, 8].

Since the main problem of NI-FECG is a low signal-to-noise ratio, the use of the AC/DC variable is the most convenient tool for the assessment of HRV. AC/DC could be calculated even in case of prolonged episodes of signal loss. The high-quality tracing for 30 minutes is an issue for the obstetrician. Therefore, the use of STV and LTV is not obvious [8, 9]. But the assessment of NST is of insufficient accuracy [3].

AC/DC is known to reflect the ability to increase or decrease heart rate [2, 5, 7]. The process of regulation captures the autonomic modulations. The lost autonomic function is a marker of a fatal event. The value of AC/DC is linked both to sympathetic and vagal activity. The disturbed AC/DC was found in myocardial infarction, heart failure, dilated cardiomyopathy, etc [5].

We have found that the application of phase rectified signal averaging in the antenatal period showed high sensitivity and specificity in fetal distress detection. Since the main problem of NST assessment is a dependence on fetal stationary condition (“sleep” or awake), we could speculate that AC/DC has a universal ability to reflect fetal deterioration.

The fetal HRV parameters are known to be associated with the process of neurological maturation. Therefore, the delay in neurological development has a negative projection on the fetal cardiovascular system [10]. The dysautonomia could be a reason for fetal compromise in growth-retarded fetuses.

CONCLUSIONS

Fetal AC/DC is a prospective option for the detection of fetal compromise during fetal growth restriction.

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Table 1. The inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
FGR diagnosed via ultrasound. The fetal weight parameters were lower than 10 th percentile	Multiple gestation, any prodrome of maternal internal disease (cardiovascular disease, renal diseases, endocrine disorders, etc.) before pregnancy

Table 2. Subject characteristics in the observed women

Clinical feature, units	Group I	Group II	Group III
Maternal age, years	22.0 ± 4.2	22.8 ± 3.9	21.9 ± 4.6
Body mass index	25.6 ± 4.4	25.8 ± 5.1	25.5 ± 5.4
Parity	1.5 ± 0.4	1.6 ± 0.3	1.6 ± 0.4
Pre-eclampsia or gestational hypertension, number of cases (%)	–	14 (29.1%)	26 (59.1%)
Early-onset FGR (before 32 weeks), number of cases (%)	–	19 (39.6%)	30 (68.2%)

Table 3. The values of AC/DC in women with FGR

Variable, units	Group I	Group II	Group III
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AC, ms	2.18 ± 0.36	1.84 ± 0.23*	1.58 ± 0.32 ^{*/**}
DC, ms	2.11 ± 0.25	1.75 ± 0.22*	1.52 ± 0.28 ^{*/**}

* — the differences were statistically significant compared to control (Group I) ($p < 0.05$); ** — the differences were statistically significant compared to Group II ($p < 0.05$)