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The comparative review of the ultrasound Doppler cardiocography (CTG) and indirect fetal electrocardiography (FECG) for assessment of fetal well-being.

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ABSTRACT

Cardiotocography (CTG) is one of the leading methods for assessment of fetal well-being and uterine activity (contractions) during pregnancy and labor. Doppler ultrasound CTG is widespread now. The comparative review of the literature and our clinical experience showed imperfections technique (Monica AN24) of fetal electrocardiography in comparison the ultrasound method CTG. Using FECG (Monica AN24) is premature in obstetrics.

Keywords: fetal hypoxia, CTG, FECG, Monica AN24.

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INTRODUCTION

Modern obstetrics nowadays has significantly improved position in reducing the frequency of antenatal and intrapartum mortality in Russia. This is due to the new three-tier system of obstetric care, the introduction of new management of pregnancy and delivery technologies to improve the quality of operative delivery and no doubt - with the diagnosis of the critical condition of the fetus. Cardiotocography is one of the methods of fetal assessment. In Russia and abroad the non-invasive ultrasound or external cardiotocography using ultrasonic sensor of fetal heart rate and strain gauge pressure sensors, or uterine tone sensors are widely spread [1-6, 10]. The automatic fetal monitors has appeared, providing computer calculation of many indicators of fetal cardiac activity with a printout for making a decision during pregnancy or in childbirth by the clinician obstetrician.

The leading reliable systems of CTG automatic analysis in Russia remain CTG (European title) or fetal monitors (American name), based on the Dawes / Redman criteria [11, 19, 21]. They are widely spread in Russian along with automatic systems based on V.N. Demidov technic [7, 8, 9].

However, in recent years, fetal monitors, based on indirect ECG have appeared on market (Monica AN24).

The aim of the study is to conduct a comparative review of the efficiency of the use of ultrasonic CTG methods and indirect ECG basing on literary sources and on the data personal clinical experience.

MATERIALS AND METHODS

A comparative review was conducted by examining the results of foreign and Russian works devoted to modern methods of CTG, including ultrasonic techniques registering fetal heart rate, compared with indirect fetal ECG, and presents our own clinical experience on the subject.

RESULTS AND DISCUSION

Years of experience in the field of CTG in Russia has shown that the ultrasonic technique with automatic registration of heart rate analysis of the CTG is reliable and highly accurate.

Redman C. in his recent article indicated that visual technique is subjective and unreliable in complicated cases of diagnosis of fetal status, especially in labor [11]. Since each cardiotocogram is individual and is 100% not similar to another. During the labor the character of labor and changes in blood flow in the mother-placenta-fetus system influences fetus well-being. Also fetus promotion through the birth canal, especially in the wide and narrow part of the pelvic cavity impacts fetus condition (+1, +2). The above-mentioned facts increases the difficulty of CTG interpreting during labor compared with the antenatal period. Only cardiotocograms computer analysis based on more than one hundred thousandth base of CTG data with the confirmed clinical outcomes, the analysis of umbilical cord blood gas or the presenting part of the fetus, allow to acieve high accuracy in assesing fetus condition.

The author indicated that Daews/Redman technique is based on the abovementioned data and is still most accurate in CTG sphere [11]. However, nowadays the systems simulating the Daews/Redman algorithms has appeared in Russia.

On the other hand, to start the computer or visual cardiotocogram analysis, you should obtain a technically high-quality chain of fetal heart rate, which results in minimal loss of signal. International standards of signal loss - not more than 15-20%.

Our experience of using fetal monitors equipped with automatic analysis by Daews/Redman has shown that signal loss averaged to 3.1% while examining 155 patients in maternity hospital No 10 (Voronezh), or 96.9% is continuous or high quality CTG recording without a significant loss of signal with the receiving of conclusion as per Dawes/Redman in 100% of cases. In other words, such minimal signal loss did not influence the evaluation algorithm and obtaining the conclusion of CTG (not a diagnosis).

Nowadays a new technique of indirect fetal electrocardiography to record heart rate and cardiogram analysis realized in fetal monitor Monica AN24 (UK) has appeared.

Using a key word Monica in PubMed we have found not more than 10 sources. Let us try to analyze the work of foreign colleagues on a comparative analysis of ultrasonic CTG techniques and indirect electrocardiography.

The main thing is that all the foreign papers are devoted to the analysis of the quality of the ECG or heart rate signal, the influence of external and internal factors to continuous cardiogram without signal loss. We did not find foreign works devoted to the study of the effectiveness of indirect electrocardiography in assessing fetal status, sensitivity and specificity, the average accuracy of the above non-ultrasound CTG technique. Obviously, this is due to low-quality recording with indirect fetal ECG that does not allow conducting accurate cardiogram analysis.

Fuchs T et al estimated signal loss during indirect fetal ECG in 773 pregnant women in terms of 28-42 weeks of gestation [12]. It was found that the average signal loss during indirect ECG was 32%. FIGO guidelines concerning signal loss - not more than 20% [12]. The recording quality corresponding the FIGO criteria for signal loss was recorded just in 46% (357/773) of pregnant women, i.e. less than 50% of the examined patients. DGGG guidelines (German Society of Gynecologists) concerning signal loss are more strict - not more than 15% [12]. The recording quality corresponding the DGGG criteria was recorded just in 39% of pregnant women, i.e. less than 40%. There was no any correlation between fetal ECG signal quality and patients BMI.

Arya B et al in their paper called Technical and Economic Assessment of Non-Invasive Electrocardiographic Fetal Monitoring in Clinical Settings indicate immaturity of fetal monitor Monica AN24 technology [13]. The recording was performed for 5-15 minutes in order to estimate ECG peaks and intervals. 60 fetal ECG from 50 mothers were taken. However adequate or quality signal was received in 20 cases with 259 fetal cardiac cycles (i.e. with fetus average heart rate of 130-140 bpm - this is about 2 minutes period) [13]. In other words, the quality ECG signal was received in 30% of cases. And what about other 70%? Further authors indicate that the assessment of intracardiac intervals is complicated from 26-30 weeks of gestation. Also in was difficult to assess QT interval. The device may be useful for evaluating atrioventricular / intraventricular conduction in fetuses from 20 to 26 weeks of gestation and > 30 weeks. However, the technical methods to improve signal detection, namely the strengthening of the T-wave, continue [13].

Reinhard J et al recommends further technical improvement of noninvasive (Monica) fetal electrocardiography comparing ECG invasive technique using STAN technology and noninvasive using Monica AN24 [14].

Therefore, they have received a quality ST segment in 3 cases of 6 while examining 6 women during the labor, which accounted for 50% of examined women [14].

Sänger N et al indicate the low quality if ECG signal recording in the second stage of labor with breech and cephalic presentation (78.4% and 55.4% respectively; $p = 0.08$), is slightly higher in the first stage, but less than 90% (87.8% and 85.7% respectively, $p > 0.05$) [15]. During 3 months starting from July 1, 2012 to September 30, 2012, the authors have evaluated only 7 cases of breech presentation using non-invasive ECG fetal monitoring. Obviously, other data (with lower recording quality or failed attempts to register indirect ECG) was removed from the study.

On the other hand, Sängner N et al [16] indicated that in general, the quality of indirect ECG recording (Monica 24™) - 77.4% was somewhat higher in comparison with ultrasonic methods (Corometrics® 250 series) - 73.1% ($p > 0.05$). However, during pregnancy in terms of 20-26 weeks of gestation, the quality of the ECG signal was significantly better comparing with that obtained by ultrasound CTG (75.5% and 45.3% respectively; $p = 0.003$).

This work can be questioned, knowing the loss of signal standards in Germany or DGGG guidelines - not more than 15% [12].

The question arises, if in this clinic the diagnostic process of CTG recording using ultrasound methods (or others) by quality fetal monitor is realized this way, so it does not meet the requirements FGGS and this work is not worth anything. The quality of record shall not be less than 85% and authors received 45.3% in early gestational age [16].

The work of Graatsma EM et al dedicated to the absence of BMI influence on fetal ECG recording quality using AN24 manufactured by Monica Healthcare can also be questioned [17].

The authors indicate that the median body mass index (BMI) of the examined women was 26.9 [17]. And this is the boundary between normal weight and overweight and is not an indicator of obesity (more than 30). Let us remind BMI formula - (Weight in Kilograms / (Height in Meters x Height in Meters)). BMI Categories: underweight = <18.5; normal weight = 18.5–24.9; overweight = 25–29.9; obesity = BMI of 30 or greater.

Thus, during the analysis of the obesity influence on fetal ECG recording quality median BMI of the examined women shall be more than 30. This work shows only the lack of influence of the mathematical body mass index in the fetal ECG recording quality, and does not prove the absence of the effect of obesity on the quality of fetal ECG recording.

German authors Reinhard J et al confirm the opposite, examining just 10 pregnant women in the period of more than 32 weeks of gestation in their work called Fetal ECG as an alternative to Doppler ultrasound in the evaluation of antenatal CTG fetal status [18].

Firstly, the small sample [18] cannot compete with thousands of studies using Daews/Redman technique with fetal monitors working ultrasound general location of the object (fetal heart).

Secondly, the pregnant women with low gestational age from 24 weeks of gestation are not included to the study. In our experience of using Monica 24 in terms of 24-30 weeks of pregnancy there is a huge loss of signal due to the small size of the fetal heart and its movements, leading to the impossibility of obtaining high-quality CTG recording [18].

Thirdly, the authors [18] confirm the low quality of the recording - for the whole period of the study 62.3% (SD +/- 30.4), in quiescent period - 75.3 % (SD +/- 33.2), and do not indicate the results in active period. However, it is clear that it should be less than 62.3%! At night (from 11 PM to 7 AM) the frequency of fetus detection was 78.3 (SD +/-25.4). The level of maternal ECG detection was higher - 99.7% (SD +/- 0.4).

Fourthly, Average recording interval [18] in fetal electrocardiography was 6 h and 54 min (SD +/- 2 hours and 43 minutes), which also coincides with our clinical experience. Ultrasonic CTG methods using Sonicaid allow receiving the automatic conclusion on the Dawes/Redman criteria starting with the 10th minute of the examination, thereby, increasing the turnover of the examined patients. According to our data, the average recording time on antenatal CTG using Sonicaid is less than 25 minutes.

In conclusion, the authors [18] suggest the need for further research in the field of fetal electrocardiography, to compare the effectiveness of two methods: ECG and ultrasound.

Summarizing the results of the examination of 154 pregnant women by outer ultrasonic antenatal CTG technique as per Demidov VN [7] on the fetal monitor "UNIKOS", in our clinic (Voronezh) we got a high average accuracy of 90% in the evaluation of fetal status, specificity - 89.4%, which confirms the findings of the Moscow authors.

In assessing the state of 229 fetuses using ultrasound outer CTG as per Dawes / Redman criteria, we have also received a high average accuracy of 90.5%, which confirms the foreign authors data [19, 21].

During the examination of 32 pregnant women by indirect fetal ECG using a fetal monitor in 2013, we have found a very low average accuracy (33%) of on-line CTG procedure in the evaluation of fetal well-being comparing with ultrasonic technique as per Daews/Redman criteria (90%).

CONCLUSION

Thus, ultrasonic methods of outer CTG are still leading and the most precision in the evaluation of fetal well-being comparing with indirect ECG (Monica AN24).

The mean accuracy of CTG ultrasound techniques with automatic analysis during fetus functional status assessment is 90%.

The few publications concerning the use of indirect ECG (Monica AN24) are limited with the studies of signal quality, which is very low. There is a large loss of signal - more than 15-20%, which does not correspond to international standards of CTG recording. Mean accuracy of on-line CTG technique on fetal monitor Monica AN24 is less than 40% as per our data.

SUMMARY

Using indirect ECG in CTG is premature and requires perfect recording quality equipment as well as further research in obstetrics.

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