Obstetrica şi Ginecologia LXV (2017) 125-130 **Review article**

THE ROLE OF INTRAPARTUM CARDIOTOCOGRAPHY IN THE 21ST CENTURY

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Abstract

Fetal heart rate monitoring by cardiotocography (CTG) detects heart rate abnormalities, which can reflect various degrees of hypoxia. The main purpose of intrapartum fetal monitoring is not so much to prevent brain involvement, which is rarely caused by intrapartum asphyxia and is strangely seen by many authors as the main reason for monitoring, as to prevent all types of early and late neonatal morbidity induced by hypoxia and acidemia. CTG during labor is associated with a reduction of neonatal seizures, but without significant differences for cerebral palsy, infant mortality or other standard neonatal well-being measures. CTG has been associated with an increase in the number of cesarean sections and instrumental vaginal deliveries. Thus, a second examination has become necessary, which is represented by new technologies such as measurement of fetal pH, fetal pulse oximetry, and ST analysis of the fetal electrocardiogram. Each of the fetal monitoring methods introduced so far into practice seems to correspond to certain clinical scenarios. However, the obtained information is limited and depends on the investigated pathophysiological mechanism.

In the 21st century, CTG continues to be the main intrapartum fetal well-being assessment method.

Rezumat: Rolul cardiotocografiei intrapartum în secolul XXI

Înregistrarea ritmului cardiac fetal prin cardiotocografie (CTG) detectează anomaliile frecvenţei cardiace, anomalii care pot reflecta grade variate de hipoxie. Scopul principal al monitorizării fetale intrapartum este nu atât prevenirea afectării cerebrale, rareori cauzată de asfixia intrapartum şi în mod curios văzută de mulţi autori ca principal motiv pentru monitorizare, cât prevenirea tuturor tipurilor de morbiditate precoce sau tardivă a nou-născutului determinate de hipoxie şi acidemie. CTG în travaliu este asociată cu o reducere a convulsiilor neonatale, dar fără diferenţe semnificative pentru paralizia cerebrală, mortalitatea infantilă sau alte măsuri standard de bine neonatal. CTG a fost asociată cu o creştere a numărului de cezariene şi de naşteri vaginale instrumentate. Astfel a devenit necesar un al doilea comentariu, reprezentat de noi tehnologii, ca determinarea pH-ului fetal, pulsoximetria fetală şi analiza segmentului ST de pe electrocardiograma fetală. Fiecare din metodele de monitorizare fetală introduse până acum în practică pare să corespundă unor anumite scenarii clinice. Informaţia obţinută este însă limitată şi depinde de mecanismul fizipiopatologic investigat.

In secolul XXI CTG continuă să fie metoda principală de screening de stare de bine fetal intrapartum.

Cuvinte cheie: cardiotocografie, auscultaţie intermitentă, pulsoximetrie, pH fetal, ECG fetal

Introduction

The electronic paper record of fetal heart rate (FHR) and uterine contractions (UC) is termed cardiotocography (CTG). For this, a Doppler transducer for FHR and a pressure transducer for UC are used. This method is called external CTG. It can be continuous or intermittent. The attachment of an electrode to the fetal scalp, known as internal CTG, requires the rupture of membranes, and the record is a fetal electrocardiogram (ECG). The term electronic fetal monitoring (EFM) is used as a synonym for CTG

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monitoring, but is less precise, because CTG includes monitoring of maternal UC, and on the other hand, there are other forms of fetal monitoring classified as electronic (for example, fetal ECG, fetal pulse oximetry) (1).

The aim of FHR recording is to detect heart rate abnormalities, which might reflect various degrees of hypoxia. The idea behind this is that detection of these abnormalities would allow obstetricians to save the fetus immediately by cesarean section or instrumental delivery, avoiding in this way asphyxia that would lead to intrapartum death or brain injury resulting in neonatal death or neurological disability (2,3). The introduction of CTG has been associated with a reduction in the number of intrapartum fetal deaths, but the problem of mortality has not been solved (4).

Intrapartum fetal monitoring methods

Intermittent auscultation

Intermittent auscultation was the predominant monitoring method during labor until CTG became widely used in the late 20th century. Although there is little evidence regarding the optimal auscultation frequency, guideline consensus is that the fetal heart should be auscultated at least every 15 minutes during the dilation period and at least every 5 minutes during the expulsion period, and each auscultation should last at least 60 seconds (1).

Intermittent auscultation is recognized as a valid management form for most low-risk cases. An increase of neonatal seizures was observed in the group with intermittent auscultation, but neurological problems did not increase in the long term. Auscultation should be frequent to be successful (a midwife for each parturient), so that CTG has become a surrogate for this quality care (5).

Cardiotocography

CTG was introduced as a screening technique in the 1970's in the belief that it would improve the detection of fetal hypoxemia and reduce cerebral palsy and perinatal mortality. Then, its use was rapidly extended from high-risk to low-risk pregnancies (5).

Researchers have shown that CTG better detects the absence or presence of fetal hypoxia than hypoxemia, acidosis and asphyxia (6). The problem with CTG sensitivity in the prediction of a poor outcome is that FHR aspects may have more than one significance (12).

CTG during labor is associated with a reduction of neonatal seizures, but without significant differences for cerebral palsy, infant mortality or other standard neonatal well-being measures. Continuous CTG has been associated with an increase in the number of cesarean sections and instrumental vaginal deliveries. CTG sensitivity for the prediction of cerebral palsy is low, with a 99.8% rate of false positive results, even in the presence of multiple late decelerations or low variability (1).

Despite imperfect sensitivity, FHR abnormalities may reflect the development of metabolic acidosis and may precede neonatal neurological depression, an abnormal neurological examination or abnormal neurological development at 1 year of age (6).

CTG tracings are frequently interpreted differently by different obstetricians (interobserver variability), and even by the same obstetrician at different times (intraobserver variability) (1,12). Such variability in the interpretation of CTG tracings leads to inadequate interventions or false fetal well-being reassurance and absence of an appropriate intervention. Intermittent auscultation is faced with similar problems, and the variability and classification of decelerations are improbable to assess.

CTG at admission to the delivery room was introduced in order to detect fetuses at risk requiring closer monitoring during labor. A study in 2017 (7), which analyzed CTG versus intermittent auscultation at admission to the labor ward, found no evidence of CTG benefits for women at low risk. In addition, the probability for CTG at admission to increase the cesarean section rates was 20%, and the authors concluded that CTG at admission should not be used for pregnant women at low risk. However, this position requires reexamination, because the concept of "low-risk pregnancy" is imprecisely defined. There are no standards for its definition, unlike in the case of high-

risk pregnancy. There is no system for the accurate prediction of high risk. In fact, it is estimated that 25-35% of pregnant women considered at low risk in the antepartum period will become at high risk during labor (8).

A study in USA, in 2013, found an increase in the use of CTG, which was associated with a modest decrease in neonatal mortality, particularly in premature babies, as well as with a 2-4% increase in the rate of cesarean sections and instrumental deliveries (9).

The main purpose of modern intrapartum fetal monitoring is not so much to prevent brain involvement, which is rarely caused by intrapartum asphyxia and is strangely seen by many authors as the main reason for monitoring, as to prevent all types of early and late neonatal morbidity induced by hypoxia and acidemia (E. Saling, 1996) (10).

Measurement of fetal pH

Because of the limitations of cardiotocography due to a relatively high rate of false positive results, additional measures and examinations have become necessary to differentiate between fetuses with heart rate abnormalities that require rapid delivery and those that can tolerate labor.

One of these is blood collection from the fetal scalp, a method introduced by Saling in 1966 for the measurement of the acid-base balance (pH, base excess/deficit). However, this is an invasive method, it requires additional expertise, is time-consuming and not free of complications (11, 12), and 3-5 scalp blood analyses are needed during labor in order to decide a cesarean section (13).

Nevertheless, it has an advantage: a fetus with metabolic acidosis will not have heart rate accelerations after painful stimulation by scalp puncture. 73% of the tested fetuses without heart rate acceleration after scalp puncture were acidemic, while the rest of 27% had no acidosis. Consequently, the absence of acceleration after scalp puncture may not be related to acidemia (6).

A randomized clinical study (14), which compared the use of CTG with fetal blood collection to CTG plus ST segment analysis of the fetal ECG, concluded that ST analysis can allow to reduce the rate of metabolic acidosis and operative deliveries, but since fetal blood collection was used in both situations, it is not clear whether this was not precisely the factor of the outcome improvement.

Fetal stimulation tests

Other methods can be used as adjuncts, for example fetal vibroacoustic stimulation, but so far there is little evidence supporting their use (1). Fetuses start to hear at 26 weeks of gestation. A fetus that responds by accelerations to an acoustic stimulation of 82-100 dB with a duration of 3-5 seconds is a viable fetus, which is not acidemic. However, up to 50% of fetuses will not present accelerations in response to vibroacoustic stimulation, although they are not acidemic (6).

Fetal scalp stimulation is easier, and it is achieved by gentle finger pressure on one of the parietal bones for no longer than 15 seconds or by applying an Allis clamp to the fetal scalp. It is a method used between contractions and between decelerations in order to obtain an acceleration that excludes acidemia. Fetal pH was higher than 7.19 when acceleration occurred within 10 minutes of stimulation. 50% of fetuses did not respond by acceleration, but only 34% of non-respondents were acidemic (6).

Fetal scalp electrode stimulation consists of gently pulling the spiral electrode, used in internal CTG, 5 times in 5 or fewer seconds. It is believed that by causing pain, it induces fetal movements followed by at least one acceleration (which excludes metabolic acidosis) in almost 95% of term fetuses, within a minute of stimulation (6).

The following have been proposed as adjuvant or alternative methods to CTG: fetal pulse oximetry; infrared spectroscopy; continuous fetal electrocardiographic monitoring with ST segment analysis (STAN method). Both pulse oximetry and fetal ECG wave analysis require access to the fetal presentation and, consequently, are invasive.

Fetal pulse oximetry

Starting from the principle of pulse oximetry in adults, direct real-time determination of fetal oxygenation during labor was introduced into practice.

When oxygen saturation of a term fetus is lower than 30% for 10 minutes (or 10 such episodes of 10 seconds each), the fetus is hypoxic, with a high risk of acidemia (6).

Doppler velocimetry and impedance in the umbilical and middle cerebral arteries are strongly correlated with pulse oximetry; there is an increase in resistivity and pulsatility indices when oxygen saturation decreases below 40% (15,16). However, Doppler velocimetry is not really useful as a monitoring test for the prediction of fetal outcome in an unselected population (17), nor is it adequate for the assessment of placental performance during labor (18). Computerized CTG supplemented with pulse oximetry has shown good efficiency and reliability in the interpretation of concerning and non-reassuring FHR patterns (19).

Although fetal oxygen saturation can be known, it has been demonstrated that this is not, as was anticipated, a reliable marker of fetal acid-base status. Nijland et al. (20) reported differences between pulse oximeter recorded values and arterial oxygen saturation values from blood samples (12.9% accuracy). Accuracy cannot be investigated in human fetuses, because no intrapartum arterial blood samples can be obtained. Saturation values higher than 30% could not demonstrate fetal well-being (21), as severe acidemia cases were also observed at this level of saturation.

In essence, the combined use of CTG and pulse oximetry did not result in an improvement of the assessed postpartum parameters – the rate of cesarean sections and neonatal prognosis (22,23).

Low oxygen saturation, although frequent in women with FHR abnormalities, is also frequent in women with normal FHR patterns (24). The same study (24) shows that this might explain why fetal pulse oximetry as an adjuvant had no benefit for the interpretation of CTG. Pulse oximetry allowed the continuation of labor in cases with non-reassuring CTG tracings, but the rate of cesarean sections for dystocia frequently increased. This might suggest that a non-reassuring CTG pattern in a normally oxygenated fetus can be predictive for imminent dystocia (24).

The sensitivity and specificity of fetal oxygen saturation for acidosis do not justify the supplementation of CTG with routine pulse oximetry (25).

Regarding infrared spectroscopy for the analysis of oxyhemoglobin and deoxyhemoglobin, meta-analyses have shown an insufficient body of evidence (26).

Fetal ECG and ST analysis

The STAN concept is based on the analysis of the ST segment (of the fetal ECG), which reflects myocardial function during a stress test. There are monitoring systems that can add automated ST segment analysis to customary CTG information. It is important to keep in mind that hypoxia has similar effects on the fetal heart and nervous system. As a result, information related to myocardial function will represent an indirect measure for the assessment of cerebral function during labor.

The ST segment becomes elevated and T wave amplitude increases or T wave inversion occurs with hypoxia and acidemia. A negative or biphasic ST segment was found in the presence of myocardial ischemia and during reoxygenation between umbilical cord occlusions (in lambs) (27). Increased T wave amplitude signifies active fetal adaptation to hypoxia, while a biphasic ST segment indicates the direct effect of the hypoxic episode on myocardial function (6).

The use of the STAN recorder resulted in a better Apgar score at 1 minute and fewer newborns with metabolic acidosis compared to the use of CTG alone (28). A meta-analysis in 2012 demonstrated no significant differences in perinatal outcomes between STAN and CTG compared to CTG alone, except for a lower rate of instrumental vaginal deliveries (29).

By using STAN technology, a small but significant decrease in the risk of postpartum acidotic status or neonatal encephalopathy was obtained. However, no significant differences were found for the cesarean section rate, Apgar score <7 at 5 min or the need for neonatal intensive care (30).

A large, carefully monitored and controlled, randomized study, as well as a Cochrane meta-analysis in 2015 showed no significant benefit of fetal ECG and additional ST segment analysis on fetal status or in reducing the rate of cesarean sections or

operative vaginal deliveries in the population of fetuses monitored by continuous CTG (31,32).

Also, another meta-analysis conducted in 2016, which included 26,529 deliveries, reported that the use of ST analysis did not improve perinatal outcome and did not reduce the cesarean section rate (33). Other studies (29,34) showed that ST analysis allowed to decrease the incidence of instrumental vaginal deliveries, as well as the need for fetal blood collection for pH measurement, but did not lead to a reduction in the incidence of metabolic acidosis at birth.

Conclusions

It can be concluded that each fetal monitoring method introduced so far into practice seems to correspond to certain clinical scenarios. However, the obtained information is limited and depends on the investigated pathophysiological mechanism.

In the 21st century, CTG continues to be the main intrapartum fetal well-being assessment method.

CTG has the advantages that it presents measurable parameters, the record can be examined at any time during labor and later on, and it can be used for clinical audits, parent counseling and medico-legal situations. However, the complexity of fetal heart rate patterns makes standardization difficult, which is a disadvantage. Another disadvantage is the fact that continuous, but not intermittent, CTG reduces the patients' mobility and their possibility of feeling better during labor. It keeps the medical staff away from the mother, and thus, CTG tends to encourage the belief that perinatal mortality and neurological injury can be prevented.

There is currently no state of the art in fetal monitoring during labor.

Probably, the correct interpretation of messages received from the fetus will truly lead us to formulate a gold standard regarding intrapartum fetal distress.

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