REVIEW ARTICLE

Fetal ECG in the Prognosis of Fetal Hypoxia

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SUMMARY

Intrapartum fetal hypoxia represents one of the most frequent causes of the hypoxia-ischemia CNS injury in newborns and it can result in the development of a permanent handicap. It often results from the underestimation of the development of the delivery by the obstetrician who conducts delivery and who is responsible for it. That is why the contemporary obstetrics is using new instruments, enabling to evaluate objectively the development of the intrapartum fetal hypoxia. The praxis consequently introduced cardiotocography (CTG), fetal pulse oximetry (FpO_2)and recently new methods for evaluation of ST interval in fetal ECG-STAN. The last method has the highest specificity for prediction of the fetal hypoxia and it properly signalises the development of the metabolic fetal acidosis, which threatens the fetus during delivery and which can impair the vital organs. Fetal myocardium sensitively responds to the release of stress hormones, to the development of anaerobic metabolism and to the increase of potassium levels. The development of hypoxia manifests in ECG as a subsequent rise of T wave, elevatuion of T/QRS segment and a significantly biphasic ST interval. The last sign indicates serious state of the fetus *in utero* accompanied with metabolic acidosis.

Key words: fetal hypoxia, ST analysis, fetal monitoring. *Po.*

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Electronic monitoring of the fetus during labour is one of the basic procedures used in modern obstetrics (1). It is undoubtedly an important tool used to reduce perinatal mortality of fetuses and the newborn (PM) (2-5).

Detection of the fetal heart rate during labour has been the practice for more than 130 years. The Pinard stethoscope[1], in its many modifications, has been the common tool over all these years. This method, however, has but a limited informative value; it is capable of monitoring heart rate only, not of providing a detailed analysis of the status of the fetus. It was not until the 1960s that cardiotocography (CTG) started being used as a diagnostic method for intrapartum fetal hypoxia. The method is capable of identifying the development of fetal hypoxia; it is not, however, capable of providing information on the severity of the hypoxia (6). Such information can be gained by applying methods developed in the last ten years – i. e. fetal pulse oximetry (FpO_2) and ST analysis of the fetal ECG using STAN S 21 equipment (7-9).

DEVELOPMENT OF FETAL INTRAPARTUM HYPOXIA

During the development of intrauterine distress, the fetus goes through several phases – hypoxaemia, hypoxia and asphyxia.

Hypoxaemia

Hypoxaemia is the initial oxygen deficit phase. The oxygen saturation of arterial blood drops, but cells and organs remain intact. Low oxygen supply activates chemical receptors in the large vessels (10). In the adult, this circumstance is manifested by increased tachypnoe, accelerated blood circulation and, eventually, by increased erythrocyte count. The fetus, on the other hand, reacts by utilizing more effectively the available oxygen. Activity is reduced as well as the amount of breathing motions and movements of the limbs. More persistent oxygen deficit slows growth. The fetus can thus cope with the situation for several days or weeks. If the situation becomes acute, stressed, then - during labour, for instance - the fetus can no longer cope, which gives rise to an acute intrapartum state of hypoxia.

Hypoxia

When the oxygen supply continues to drop, the defence mechanism becomes weakened and the oxygen deficit starts affecting peripheral tissues. The first reaction is the washout of stress hormones (adrenaline, epinephrine, noradrenaline) from the adrenals and the reduction of peripheral blood circulation (5). This triggers the redistribution of circulation towards the central organs – the heart and brain (11-13). Anaerobic metabolism occurs at the periphery and blood circulation increases three to five-fold.

[1] stethoscope - metal or wooden instrument for monitoring fetal sounds through the mother's abdominal wall

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Adrenaline washout activates beta-receptors located on cell surfaces, which leads to the activation of cyclic AMP and, simultaneously, to the activation of phosphorylase. By glycogenolysis, the latter enzyme converts glycogen into free glucose, thus starting anaerobic metabolism (13-16). If the fetus is delivered early enough, the situation can be managed – i. e. if delivery occurs within a few hours.

Asphyxia

Asphyxia implies enhanced risk of vital organ failure. The fetus reacts by maximum activation of the sympathetic division and of stress hormones. Anaerobic metabolism occurs in the central organs, the fetus uses liver and heart muscle glycogen reserves (17). The brain has a very small supply of glycogen and is therefore supplied by glucose mainly from the liver. The fetus is still straining to redistribute blood to the central organs. If the status approaches the terminal stage, the whole system collapses, both heart and brain fail (10, 17). This is manifested by terminal fetal bradycardia; the fetus may be saved if delivered within a few minutes.

THE PRINCIPLE OF ST ANALYSIS OF FETAL ECG (STAN) METHOD

The method was developed in Sweden and is beginning to be applied on a wider scale in a number of other countries (Fig. 1). The fetal ECG is traced by a spiral electrode placed on the presenting part of the fetus (head, breech). The signal is transferred to an analyzer; it is filtered and evaluated by a software programme (Fig. 2). The ST segment of the fetal ECG responds with great sensitivity to fetal distress and reduction of oxygen supply to the myocardium (12, 18). Beta-adrenergic receptors and anaerobic glycogenolysis are activated in hypoxaemia. This releases lactic acid as well as potassium, leading to a change of the potential in the cellular membrane of myocardial cells (10, 15, 17). On the ECG this is manifested by the elevation of the ST segment. Hypoxaemia also stimulates adrenaline secretion, which increases the contraction activity of the myocardium and induces glycogenolysis. This is manifested by T wave elevation on the ECG. When hypoxaemia turns into hypoxia, a depression of the ST segment occurs. The myocardium is no longer able to respond to oxygen deficit and cope with the deepening state of hypoxaemia (10, 19). The biphasicity of the ST segment is a sign of imminent myocardial ischaemia, severe fetal hypoxia and progression of metabolic acidosis (15, 16). In such circumstances, labour must be terminated immediately.

CHANGES IN THE ST RECORD-ANALYZER

T wave elevation

The elevation of the T wave is a classical reaction of the fetus to hypoxia. It is a response to adrenaline washout and to anaerobic metabolism of the myocardium (20, 21). The fetus is capable of coping with short-term hypoxia if the myocardium contains the required amount of glycogen (Fig. 3).

Episodic T/QRS elevation

The T/QRS sections ration is elevated but returns to normal within 10 minutes. The apparatus can record this state if the T/QRS ratio is higher than 0.10. Episodic elevation of this complex corresponds with short-term hypoxia, during which the fetus utilizes the anaerobic metabolism to support heart function (11). This phenomenon is significant in the presence of a simultaneous pathological CTG record. In such case labour must be terminated (Fig. 4).

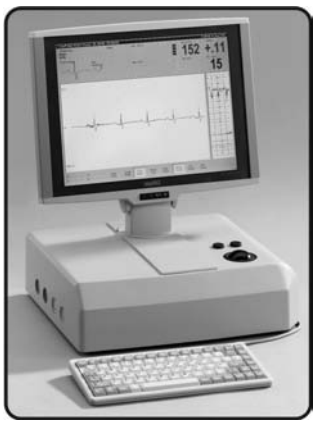

Fig. 1. STAN S 21 fetal monitor

Elevation of the T/QRS baseline

The apparatus will record this phenomenon if the elevation lasts longer than 10 minutes and is larger than 0.05. This reflects a situation when the fetus is exposed to hypoxia and anaerobic metabolism (13). The fetus can usually compensate for this and, if the CTG record is normal, labour can continue *per vias naturales* (Fig. 5).

Biphasicity of the ST segment

The fetal heart has no more reserves to be able to manage the hypoxia and there is danger of heart failure (11). Biphasicity has three degrees, and especially the second and third degree is explicitly pathological and labour must be terminated immediately (Fig. 6).

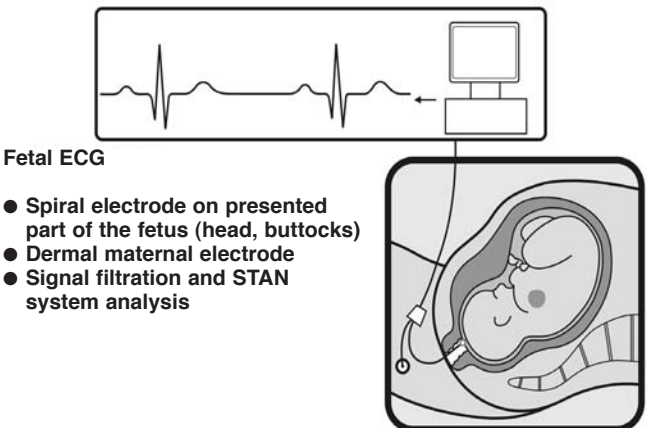

Fig. 2. Principle of fetal electrocardiography method

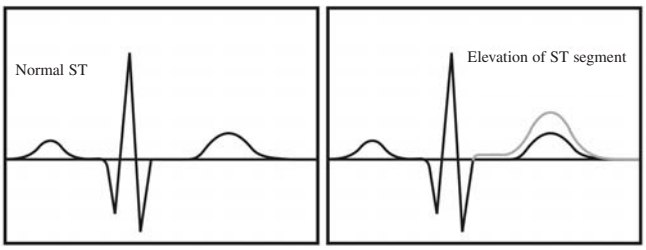

Fig. 3. T wave elevation on fetal ECG

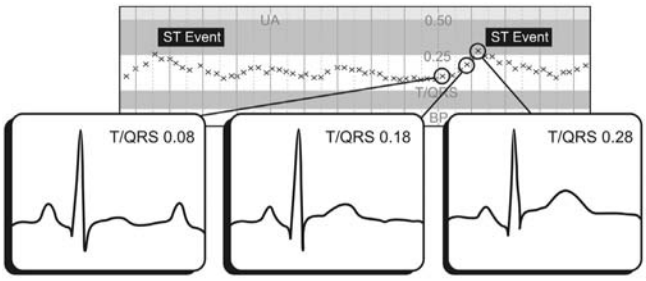

Fig. 4. Episodical elevation of T/QRS segment

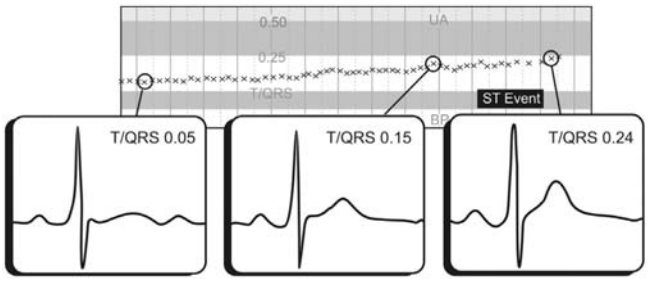

Fig. 5. Elevation of base line

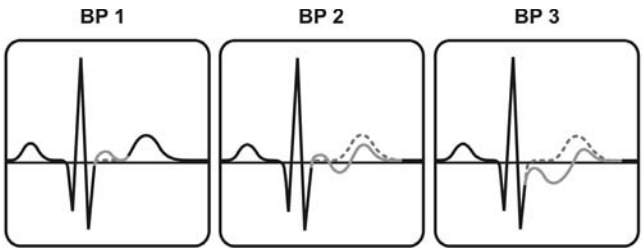

Fig. 6. Biphasal ST segment

CONTEMPORARY OBSTETRIC EXPERIENCE IN ST ANALYSIS

The most extensive experience in the new method has been presented by a randomized Swedish study published in 2001, which evaluated 4,966 deliveries, where one group was monitored by CTG alone and the other group by CTG + STAN (13). Application of ST analysis resulted in a significant reduction of intrapartum fetal hypoxia connected with metabolic acidosis. On the other hand, this method contributed to a reduction in the number of surgical deliveries, especially to a reduction in the frequency of Caesarian sections often indicated on the basis of allegedly pathological CTG records (6, 18, 19, 22).

A grant project is currently underway at the Gynaecological and Obstetric Clinic of the 1st Faculty of Medicine of Charles University and of the General Teaching Hospital in Prague, comparing three methods applied to diagnose intrapartum fetal hypoxia (CTG , FpO_2 and STAN). The cases concluded so far indicate that it is ST analysis which has the highest prognostic value for intrapartum hypoxia (8).

CONCLUSION

A new method of detecting intrapartum fetal hypoxia - ST analysis of the fetal ECG – utilizes the sensitivity of the fetus to changes in the insufficiency of oxygen supply during labour. It is capable of early interpretation of the development of fetus hypoxia and allows early termination of labour to avoid severe hypoxic-ischaemic changes of vitally important organs, especially the brain. The fetal myocardium reacts sensitively to the washout of stress hormones, the development of anaerobic metabolism and changes in potassium levels. The ST analyzer is capable of interpreting these changes on the fetal ECG from T wave elevation, to elevation of the T/QRS segment, to very marked biphasicity of the ST segment which points to a very severe or even terminal status of the fetus *in utero*.

Abbreviations

AMP	adenosinmonophosphate
CNS	central nervous system
CTG	fetal cardiotocography
FpO_2	fetal pulse oximetry
PM	perinatal mortality, number of deaths of fetuses and neonates before the 7th day of life per 1,000 live born children (per mille)
STAN	ST analysis of fetal ECG

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