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Research Article

Natural Periods of Fetal Hypoxia During Vaginal Childbirth are a Unique Physiological Phenomenon. Why Women should know about it

Natalya A Urakova[1] and Aleksandr L Urakov[2]*

[1]PhD, Associate Professor of the Department of Obstetrics and Gynecology, Izhevsk State Medical Academy, Izhevsk, Russia

[2]DM, Professor, Head of the Department of General and Clinical Pharmacology, Izhevsk State Medical Academy, Izhevsk, Russia

***Corresponding Author:** Aleksandr L Urakov, DM, Professor, Head of the Department of General and Clinical Pharmacology, Izhevsk State Medical Academy, Izhevsk, Russia.

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Abstract

Normal physiological childbirth is impossible without uterine contractions. Periodic uterine contractions during vaginal delivery inevitably cause temporary periods of intrauterine vasoconstriction and decreased delivery of arterial blood and oxygen both to the uterus itself and to the placenta and to the fetus inside the uterus. Moreover, the stronger and longer the uterine muscle contractions develop, the stronger and for a longer period they squeeze the uterine vessels and reduce blood flow in them. Therefore, short periods of uterine and placental ischemia are inevitable in natural childbirth, just as short, repeated periods of intrauterine hypoxia are inevitable. Consequently, natural intrauterine hypoxia is a physiological phenomenon that accompanies the birth of every child in a physiological childbirth, and every fetus is normally prepared to withstand such a test of hypoxia. However, an excessively long period of fetal hypoxia and/or exhaustion of fetal adaptation reserves to hypoxia can cause hypoxic damage to brain cells and fetal death. Recent advances in the diagnosis of fetal intrauterine hypoxia, assessment of fetal resistance to hypoxia, and new clinical strategies based on these findings are presented.

Keywords: Pregnancy; Birth; Fetus; Resistance to Hypoxia; Diagnostics

Introduction

Intrauterine fetal hypoxia remains the main cause of perinatal morbidity and mortality in all countries of the world. Since ancient times, mankind has not been able to defeat it completely. One of the reasons for our impotence in front of her is the lack of an affordable and reliable method for timely diagnosis of intrauterine hypoxia. The second reason for our weakness in front of her is the lack of a method for assessing fetal resistance to hypoxia [1,2]. At the same time, it is clear to us that the threat of hypoxia lies in the fact that it can cause the development of hypoxic damage to brain cells of an irreversible nature [3]. There is no doubt that the severity and nature of perinatal lesions of the child's brain depends on the localization and size of the focus of irreversible hypoxic damage to fetal brain cells. In addition, it is clear to us that after the birth of a child, these brain lesions can cause not only minor cerebral disorders and cerebral palsy, but also decortication and even its death [1-4].

On the other hand, it was found that the adaptive response of the fetus to hypoxia is a redistribution of blood flow to the fetal brain, known as the "brain preservation effect" [1,5,6]. This

phenomenon has attracted the attention of many researchers. As a result, an ultrasound method was proposed to assess the degree of redistribution of fetal blood flow in favor of the fetal brain. However, the introduction of this method did not prevent hypoxic damage to fetal brain cells. Today it is already obvious that this adaptive mechanism is insufficient and not omnipotent, especially in cases of excessively prolonged hypoxia. It is reported that ultrasound evaluation of blood flow redistribution using the brain/umbilical cord Doppler ratio does not guarantee the safety of the fetal brain during hypoxia [5,6]. In addition, the sonographic diagnostic method is not available to all pregnant women [7]. At the same time, the risk of intrauterine hypoxia for fetal health is increasing with every second, not just with every minute. That is why an emergency diagnosis of hypoxia is very important, which is possible only by the pregnant woman herself. At the same time, it is equally important to assess in advance the resistance of the fetus to hypoxia and the availability of reserves for its adaptation to it. It is hoped that these problems can soon be solved with more success than yesterday, as the introduction of telemedicine and artificial intelligence can help us to do so [8].

Voluntary maternal apnea as a model of short-term intrauterine hypoxia

It is reported that intrauterine hypoxia can occur due to various pathological conditions of the mother, placenta and fetus. Therefore, it is believed that intrauterine hypoxia can manifest itself in different ways [4]. Based on this, it was proposed to divide intrauterine hypoxia into pre-placental, uteroplacental and post-placental hypoxia [9]. At the same time, as an example of a true hypoxic pathology of the fetus, it was suggested to consider high-altitude hypoxia, since fetal hypoxia, which develops only high in the mountains, occurs solely due to a decrease in the oxygen content in the inhaled air, and not due to any other reasons [4]. However, this approach did not meet expectations due to low availability and high danger. At the same time, there is no accessible and safe model of intrauterine hypoxia, which greatly hinders the progress of her research.

At the same time, there is a test for adult resistance to hypoxia. It was developed by Vladimir Stange [10]. For this purpose he proposed to measure the maximum possible duration of voluntary apnea [11]. This test has been used in medicine for more than 100 years, and nobody doubts that measuring the maximum possible duration of respiratory arrest in a pregnant woman can give information about her body's resistance to hypoxia. This wouldn't surprise anyone. Most surprisingly, the possibility of using maternal apnea to model fetal intrauterine hypoxia has gone unnoticed! However, apnea of a pregnant woman allows to simulate hypoxia not only in her body, but also in the body of her fetus. At the same time, voluntary apnea is available to all mothers in all countries of the world, and hypoxia caused by breath-holding is safer than altitude hypoxia.

At the same time, the Stange test is not intended to assess fetal resistance to intrauterine hypoxia. The fact is that the resistance to hypoxia in the mother and her fetus may be different. In this regard, in some cases, maternal apnea may be completely safe for the mother, but not for her fetus, which may receive hypoxic damage to its brain [12].

However, the idea of using maternal apnea to assess fetal resistance to hypoxia was very appealing from the beginning, because apnea can be easily used not only by the physician but also by any pregnant woman as a standard model of fetal hypoxia [13]. For the successful use of the Stange test in obstetrics, it lacked only complete safety for the fetus and the addition of real-time monitoring of fetal resistance to hypoxia. Today we can gladly declare to the whole world that these tasks have been solved in Russia.

How stopping oxygen changes the condition of fish in the water and fetuses in the amniotic fluid and how we can use this in obstetrics

It is known that the oxygen demand of the fetal brain progressively increases from the beginning of the 2nd half of pregnancy [2,4]. At the same time, mechanisms of fetal adaptation to hypoxia begin to form. This is due to the fact that periods of short-term periods of a decrease in the oxygen content in the mother's blood are possible with accidental respiratory retention, with a defect in the development of the placenta or with a contraction of the uterus during physiological childbirth. Moreover, the fetus is preparing to successfully withstand the biggest hypoxia tests that "await" it in vaginal childbirth. The fact is that the most frequent and prolonged periods of intrauterine hypoxia develop during

natural childbirth. Moreover, the degree of hypoxia and its duration increase with the intensification of labor activity of the uterus [2]. This is due to the periods of development of placental ischemia, which occurs due to the fact that at the end of vaginal childbirth the strongest muscle contractions of the myometrium develop, which inevitably squeezes the intrauterine vessels. It is reported that normally the fetus is ready for these periods of hypoxia and easily withstands them. At the same time, from the very beginning of hypoxia, the fetus stops motor activity and is at rest [12,13]. Therefore, normally, his mother also "does not notice" a change in the "behavior" of the fetus inside the uterus during accidental hypoxia, potentially safe for her fetus. However, when the fetus's reserves of resistance to hypoxia are exhausted, the fetus's attitude to hypoxia changes dramatically, since in these conditions hypoxia begins to threaten its life from the first seconds.

It has been found that during maternal apnea, the motor activity of fetuses in the amniotic fluid inside the uterus resembles the motor activity of aquarium fish inside a hermetically sealed container when the oxygen supply to them is terminated [12-14]. In particular, when fetuses and fish have sufficient adaptation reserves to hypoxia, they are in a motionless state, and sudden motor activity occurs in them only when the adaptation reserves to hypoxia are exhausted. In this case, the ray-like properties of the fins change, gill fin movements appear, the gill arches breathe, the mouth opens, and the fish start swallowing water with their mouths wide open. Fetuses in a similar situation begin to change the ultrasonic echogenicity of the finger pads, there are breathing movements of the chest, there are sudden movements of the arms and legs, the fingers of the hands, which were previously in a compressed state, straighten. Due to ultrasound monitoring of fetal motor activity inside the uterus, it was found that normally, during maternal apnea, fetuses remain motionless for more than 30 seconds. In this case, they have no respiratory movements of the thorax, their arms and legs remain pressed against the torso, their fingers remain clenched into fists, the ultrasound echogenicity of their fingers remains unchanged, and their mouth remains closed.

In this regard, it has been proposed to assess with ultrasound the fetal resistance to intrauterine hypoxia by the maximum duration of its motionless state inside the uterus from the onset of maternal apnea (RU Patent No. 2432118, 10/27/2011; RU Patent No. 2511084, 04/10/2014; RU Patent No. 2529377, 09/27/2014). It has been proposed that fetal immobility more than 30 seconds after the onset of maternal apnea is an indicator of good fetal resistance to hypoxia, and fetal respiratory chest movements less than 10 seconds after the onset of apnea have been proposed to be an indicator of poor fetal resistance to hypoxia. On this basis, it has been proposed that good fetal resistance to hypoxia is an indication for vaginal childbirth and poor fetal resistance to hypoxia is a contraindication for vaginal childbirth. Moreover, it has been suggested that poor fetal resistance to hypoxia should be considered as an indication for C-section childbirth.

To this we should add a Russian invention in which monitoring of the dynamics of ultrasound echogenicity of fetal fingertip fingertips was proposed to assess the fetal adaptation reserves to intrauterine hypoxia (RU Patent No. 2441592, February 10, 2012). It has been reported that decreased echogenicity of the subcutaneous fatty tissue of the fetal fingertip pads occurs in severe fetal hypoxia that threatens the viability of fetal cortical cells. Normally, the echogenicity of the fingertip pads is restored between periods of myometrial contractions. However, in some cases, the echogenicity of the fetal fingers is not restored between periods of uterine contractions during natural childbirth. This is bad, because it indicates exhaustion of the fetal adaptation reserve to hypoxia. Therefore, in such cases, it was recommended to immediately increase maternal blood oxygen saturation to toxic values and/or to immediately apply Cesarean section to preserve the fetal brain cells [12-14]. In Russia it was shown that ultrasound echogenicity of fetal and adult finger pads can be used to diagnose hypoxia because it reflects the oxyhemoglobin content in their blood.

Discussion

From the second half of pregnancy there is a progressive increase in fetal oxygen requirements and the likelihood of hypoxia, the excessive duration of which can cause various diseases and even fetal death [1,12]. There is no doubt that the onset of periods of fetal hypoxia is almost inevitable during physiological childbirth. The fact is that during vaginal childbirth the uterus periodically and repeatedly squeezes the intrauterine blood vessels and causes repeatedly consecutive periods of placental ischemia. The longest periods of placental ischemia and fetal hypoxia occur at the end of physiological childbirth, because in this period of childbirth the

uterus contracts most strongly and for a long period [2]. However, the duration of each individual period of uterine contractions does not exceed 60 seconds [15]. In addition, the uterus is not able to fully constrict its blood vessels throughout this period, because the value of myometrial muscle tone increases gradually each time, rather than in a flash, and after reaching the maximum value, uterine tone decreases again [2-4]. In this regard, the dynamics of uterine contractions are synoidal [15]. Therefore, during physiological childbirth, the longest period of natural fetal ischemia caused by uterine contractile activity barely reaches 30 seconds. That is why, normally, during vaginal childbirth, a period of placental ischemia and fetal hypoxia occurs only in the middle of each uterine contraction and is absent in the intervals between them.

Despite the fact that the danger of fetal hypoxic brain damage during physiological childbirth is not disputed by anyone, the world still lacks a standard and accessible technique for urgent assessment of fetal resistance to periods of hypoxia in real time. At the same time, no one disputes the fact that when fetal adaptation reserves to hypoxia are exhausted, Cesarean section is the way of immediate fetal salvation [16,17]. However, it is surprising that there are no standard criteria for choosing Cesarean section as an alternative to vaginal childbirth in life-threatening fetal cases.

In Russia from 2012 to 2022 it was found that the main danger to the fetus is not so much hypoxia, but rather the exhaustion of the fetus's reserves of adaptation to it. The fact is that when the fetus is well prepared for vaginal childbirth (i.e. in normal), it has a good resistance to natural periods of hypoxia in vaginal childbirth. This is why if the fetus is well resistant to hypoxia, it will easily withstand the ordeal of periods of uterine asphyxiation and remain healthy. In all likelihood, successive intermittent periods of uterine asphyxiation of the fetus play the role of the last training of the fetus to mobilize all its reserves for successfully overcoming the final and longest period of hypoxia in vaginal childbirth. Incidentally, this period normally does not exceed 30 seconds!

At the same time, women and obstetricians worldwide continue to ignore the inevitability of a unique physiological phenomenon during vaginal childbirth in the form of normal periods of intrauterine fetal hypoxia caused by uterine contractile activity lasting up to 30 seconds. Because of this, fetal readiness for upcoming periods of hypoxia during vaginal childbirth is still not assessed by obstetricians. This problem has not been solved because there is no functional test for fetal resistance to hypoxia in the standard of obstetric care. However, we once again express the hope that it is the new functional test for fetal hypoxia resistance in maternal apnea, available to every pregnant woman for self-assessment at home in real time, that can improve the prognosis of pregnancy and vaginal childbirth. In addition, this functional test can simultaneously be used to select the type of childbirth [18]. In other words, a functional test with maternal apnea may be the first criterion for choosing a C-section.

In this regard, we once again inform you that each pregnant woman can independently assess the resistance of her fetus to hypoxia using a modified Stange test [18]. To do this, woman need to hold her breath, take time and wait for the moment when the fetus starts "knocking" its arms, legs or head on the uterus, which indicates the depletion of fetal adaptation reserves to hypoxia. When this "distress signal" is received from the fetus, the mother can immediately stop apnea and resume breathing. Therefore, the mother can easily determine the duration between the onset of apnea and the time she receives the "distress signal" from her fetus [19]. When the fetus does not give a "distress signal" within 30 seconds of the onset of apnea, it has good resistance to hypoxia. In this case, the prognosis of vaginal childbirth is favorable. In the case where the fetus gives the "distress signal" immediately after the onset of apnea (up to 10 seconds from the onset of maternal apnea), it has low resistance to hypoxia, so childbirth through the natural birth canal is contraindicated. The fact is that if the fetus has low resistance to hypoxia, the fetus may drown in amniotic fluid, or the newborn may develop asphyxia, encephalopathy, or pneumonia. If this is the case, only a planned C-section can improve the prognosis for childbirth.

Conclusion

Thus, the known Stange test is not suitable for diagnosing intrauterine hypoxia and assessing fetal resistance to it. However, supplementing this test with ultrasound and/or tactile monitoring of fetal motor activity allows the mother to assess the resistance of her fetus to hypoxia. The duration of fetal immobility during maternal apnea of 30 seconds or more indicates good fetal resistance to hypoxia and predicts a good outcome of vaginal

childbirth. In turn, the occurrence of vigorous fetal motor activity up to 10 seconds after the onset of maternal apnea indicates low fetal resistance to hypoxia and a high probability of a poor vaginal childbirth outcome. However, in this case, the outcome of childbirth can be improved by immediate C-section.

We believe that a modified Stange test will be introduced to assess fetal resistance to hypoxia, to physiological childbirth and to select the type of childbirth in real time. This will be helped by the initiative of pregnant women around the world, as well as the introduction of telemedicine and artificial intelligence.

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