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Review Article

A drowning fetus sends a distress signal, which is an indication for a Caesarean section

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ABSTRACT

The review is devoted to the prevention of neonatal asphyxia by assessing the reserves of adaptation of the fetus to intrauterine hypoxia in the second half of pregnancy and then choosing a safe type of delivery. The history of development of a new functional test that provides a non-invasive assessment of fetal adaptation reserves to intrauterine hypoxia using sonography is shown. It is proposed to use ultrasound to determine the duration from the beginning of apnea in a pregnant woman to the appearance of a distress signal, the fetus inside the uterus when its reserves of adaptation to hypoxia are exhausted. If a distress signal appears earlier than 10 seconds from the start of breath retention of pregnant woman is recommended to refuse of physiology birth and is offered delivery by Cesarean section.

1. Introduction

According to the World Health Organization, perinatal asphyxia is one of the three common causes of under-five child mortality (11%) following preterm birth (17%) and pneumonia (15%).[1] However, it is sad that the diagnosis of perinatal asphyxia is made only after the completion of labor. The diagnosis of perinatal asphyxia is made when the umbilical cord arterial pH is <7, the APGAR (Appearance, Pulse, Grimace, Activity, and Respiration) score is 0-3 at the fifth minute, and there are central nervous system manifestations like seizures, lethargy, coma, hypotonia, or hypertonia and multisystem organ dysfunction.[2]

Therefore, even after the completion of labor, the newborn remains for some time without assessing the state of their health and the degree of hypoxia. That is why modern standards of obstetric care do not exclude the harmful effect of intrauterine hypoxia on the fetus. It is very tragic that hypoxia is the first to damage brain cells.[3–5]

Virginia Apgar developed in 1953 the Apgar scoring which has shown relevance in assessing the general well-being of the newborn at delivery and also determining the response and effectiveness of resuscitation.[6–8] The Apgar scoring still remains an important tool in newborn assessment and monitoring the progress of resuscitation in a resource-poor setting.[6]

Unfortunately, in gynecology and obstetrics, there is still no officially recognized scale for evaluating the adaptive ability of the fetus to the tests that it will face during physiological childbirth. Long-term labor, the presence of meconium-stained amniotic fluid, and preeclampsia are considered irrefutable evidence of possible perinatal asphyxia.[9]

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Therefore, we can conclude that the prediction of neonatal asphyxia has not improved dramatically over the past few hundred years.

In particular, to reduce neonatal mortality, it was proposed to improve prenatal care, monitor mothers during childbirth with a partograph, improve emergency obstetric care, and improve skills of doctors in neonatal resuscitation and management of sick newborns.[10] But the implementation of these recommendations is also not able to predict and exclude neonatal asphyxia.

At the same time, it has long been known that a Caesarean section can reliably protect the child's brain from the tragic tests that it may be subjected to during physiological childbirth. This operation was the first carried out, at least, in the year 715 BC.[11] In 2012, about 23 million Caesarean sections were performed worldwide, and it is claimed that more widespread use of Caesarean sections may lead to better outcomes.[12]

However, there is no officially recognized rating scale for fetal adaptation to the upcoming intrauterine hypoxia in childbirth, which would be the basis for the indication for a Cesarean section that can exclude neonatal asphyxia.

It is believed that the indication for a Caesarean section is a difficult birth, a double pregnancy, high blood pressure in the mother, childbirth in the buttock area, or problems with the placenta or umbilical cord.[11,12] Among these indications there is no conclusion about the low resistance of the fetus to intrauterine hypoxia during pregnancy and before childbirth. However, such recommendations have already been given to obstetricians and gynecologists

In this regard, to improve the quality of obstetric care and preserve the health of the fetus and newborn at the risk of hypoxic damage to brain cells during physiological childbirth, it makes sense to pay attention to innovations that have not been noticed by the international community of obstetricians and gynecologists.

2. Materials and Methods

There was a thorough study of inventions and scientific articles published between 2010 and 2020 in the databases E-Library, EAPATIS, PATENTCSOPE, Google Patent, Google Scholar, Scopus, PubMed, Science Direct and Yandex. The results were analyzed, prioritized, and summarized. Keywords of the search strategy: childbirth, fetus, fetal brain, cerebral cortex, neonatal asphyxia, intrauterine hypoxia, oxygen, pregnancy, apnea, resistance, sonography, diagnostics, adaptation to hypoxia, The information was limited to the possibility of using it at the end of pregnancy, before or during delivery to assess the resistance of the fetus to intrauterine hypoxia. 12 inventions were evaluated for review.

3. Objective

This review is intended to show the significance of sonographic research of fetal motor activity dynamics during a pregnant woman holds her breath in order to determine the fetal resistance to hypoxia during the upcoming physiological delivery, on the one hand, and the diagnostic value of fetal resistance to apnea indicators in order to choose a safe type of birth for the fetus, namely, by physiological delivery or by Cesarean section.

4. Results

Almost 100 years ago, the great physiologist Sir Joseph Barcroft stated that during pregnancy and physiological childbirth, occurring in different conditions, fetuses are subjected to intrauterine hypoxia of varying degrees of severity.[13] But, Sir Joseph Barcroft believed that natural adaptation to hypoxia does not completely protect people from the harmful effects of lack of oxygen. In particular, he stated that high-altitude hypoxia reduces the mental and physical abilities of people.[14]

It was shown that evolution has given the lungs, blood, and placenta of a pregnant woman and the brain of a fetal an adaptation to hypoxia.[13–17] However, there is no mention of a functional test for fetal resistance to acute intrauterine hypoxia.[14,16,17] Official obstetrics and gynecology do not have a standard functional test to assess the reserves of adaptation of the fetus to intrauterine hypoxia before delivery.

At the same time, adult reserves of adaptation to acute hypoxia for more than 100 years are estimated by the maximum possible duration of voluntary apnea. This method was proposed by the Russian researcher V.A. Shtange and is called "Shtange test".[18] In 1914, V.A. Stange, of Petrograde, found that average healthy persons could hold the breath for from 45 to 50 seconds, while patients with weak heart muscles could do so but for from 10 to 20 seconds. While V.A. Stange seemed to have had no suspicion that the breath-holding test was based on an apnea due to decreased alkaline reserve, nevertheless he reported observation on number of chronic diseases, in which he found the duration of the apneic pause shortened in about the degree in which so-called acidosis is known to occur from the results of the observes.

About 10 years ago in Russia, the principle of the Shtange test was used as the basis for a functional test to assess the adaptation of the fetus to intrauterine hypoxia.[19,20] Just before that it was invented «N.A. Urakova's intrauterine scuba and ventilation method of fetal lungs with respiratory gases» (RU Application N 2010134466. 17.08.2010) and «The way of saving the fetus in case of sudden intrauterine hypoxia» (RU Application N 2011109952. 16.03.2011). In these inventions it is proposed to use sonographic monitoring of fetal motor activity inside

the uterus. To protect the fetus from death in intrauterine hypoxia, it was proposed to immediately hyperventilate the lungs of the pregnant woman and the fetus with respiratory gas. At the same time, for ventilation of the lungs of the fetus inside the uterus, it was proposed to use a special intrauterine scuba tank, which was proposed to be put on the fetal head under the ultrasound control. Regardless of this, if intrauterine hypoxia persists, it was suggested to perform an urgent Caesarean section in order to start natural ventilation of the lungs of the fetus as soon as possible with the surrounding air.

In order to use the Stange test to assess fetal adaptation to intrauterine hypoxia, a non-invasive method was developed to diagnose the distress signal that the fetus sends to its mother that it has exhausted all its reserves of adaptation to hypoxia and that it urgently needs oxygen. But before that, it was necessary to open such a signal. The fact is that no one has set such a task before. Therefore, no one even thought about the fact that the fetus can give a distress signal to its mother that it has exhausted all the reserves of adaptation to intrauterine hypoxia and that it urgently needs to be given oxygen.

Interestingly, the nature of this distress signal was suggested by fish. The fact is that aquarium fish of the guppies breed, blue neons and swordfish were used in experimental modeling of intrauterine hypoxia of the fetus.[21–25] When simulating acute fetal hypoxia, each aquarium fish was placed in a transparent, colorless plastic container with 5 ml of water at a certain temperature. Hypoxia of fish was modeled by the fact that the container was hermetically closed and thus stopped the flow of air into the water in which the fish was swimming. From this point on, this fish was videotaped in passing light until the death of the fish, which occurred from acute hypoxia. In these experiments with aquarium fish, it was first found that adult healthy aquarium fish respond to acute hypoxia by a characteristic change in their motor activity. It was found that during the initial period of hypoxia, fish have a stationary state, in which they stay for as long as their available reserves of adaptation to hypoxia allow. Then at the beginning of exhaustion of reserves of adaptation to hypoxia fishes are excited, open your mouth wide, actively and often chased gills water through the mouth and gill arch, increase to maximum values of vibrational motion of side fins, tail and body, rushing to the water in a chaotic twitching of the entire body. At the end of this period, the fish defecate in the water. After this, the body of the fish becomes motionless and sinks to the bottom of the container, where it turns upside down with its belly. After that, it slowly floats into the upper layers of the water and dies.[22]

In parallel with this, in clinical conditions was carried out monitoring of motor activity of healthy fetuses in the womb with the voluntary delay of its breath. Dynamics of fetal motor activity was performed sonographically. The results showed that voluntary apnea causes fetal hypoxia, which is manifested by characteristic changes in its motor activity. It turned out that the dynamics of fetal motor activity during apnea almost exactly repeats the dynamics of motor activity of fish in their acute hypoxia in the water.[21,23]

It has been convincingly shown that in normally, when pregnant women hold their breath, their fetuses immediately become motionless and they may be in this state for a while. Then the duration of the motionless state of the fetus during apnea continues depending on their resistance to hypoxia: the more reserves of adaptation to hypoxia, the longer the fetus remains motionless. When the reserves of adaptation to hypoxia are exhausted, the fetus develops continuous and erratic convulsive twitching throughout the body. However, a second before this, there are sudden "breathing" movements of the ribs of their chest. However, the oral cavity of the fetus remains closed.[26,27]

In a different way, the motor activity of the fetus changes in the case of pregnancy pathology. Thus, in fetoplacental insufficiency, apnea does not immobilize the fetus, but stimulates its motor activity. In severe fetoplacental insufficiency, apnea increases fetal motor activity, periodic active respiratory movements of the ribs, convulsive twitching of the limbs and the entire body are detected. Very quickly, the arms are unbent and the fists are unclenched, the fingers are almost completely straightened, the anal opening opens and feces are released. Therefore, in this situation, the meconial masses are in the amniotic fluid, are divided into small parts due to the destructive effect exerted on them by mechanical blows of the fetal body parts and hydrodynamic blows of the amniotic fluid flows, due to overly active erratic convulsive twitching of all parts of the fetal body. Then when the hypoxia deepens and lengthens, the fetus opens its mouth, chokes on amniotic water and drowning in it.[21,26,28,29]

It is important to emphasize that studies of how acute hypoxia affects the motor activity of fish in experimental conditions and fetuses in the clinic allowed to make the following very important discovery. It has been proved that in acute hypoxia, fish in the water and fetuses in the liquid inside the uterus behave almost the same: when hypoxia occurs, they stop their motor activity and take a stationary position, which they maintain until their reserves of adaptation to oxygen deficiency are exhausted. It was found that when the reserves of adaptation to hypoxia are exhausted, fetus and fish begin to "sound the alarm", namely, they suddenly begin to make active respiratory movements with the chest (fetuses) or mouth and gills (fish), convulsively twitch their entire body and limbs (fetuses) or fins and tail (fish). At the end of the fetus and fish defecate fecal masses and choke (fetuses) "dirty" liquid or intensively pass it through the open mouth and gill arches (fish).[21,22,26]

The correctness of these adaptation symptoms was confirmed by experiments with the introduction of oxygen and/or a solution of hydrogen peroxide into the water in which fish swim, or into the body of a pregnant woman.[24,25] On this basis it was proposed to use a solution of hydrogen peroxide to preserve the life of fish during storage and transportation and to preserve the life of children and adults in hypoxia.[30–34]

Analysis of these data allowed us to conclude that the immobile state of live fetus and fish in acute hypoxia can serve as a diagnostic symptom of their well-being and the sufficiency of their reserves of adaptation to oxygen deficiency. On the other hand, the appearance of active respiratory movements of the ribs and chest (fetus) or gill arches and mouth (fish), combined with erratic convulsive twitching of the entire body, can serve as a diagnostic symptom of the beginning of exhaustion of the reserves of adaptation to hypoxia and a distress signal of the need to urgently increase the delivery of oxygen. In turn, the appearance of feces in water can serve as a diagnostic symptom of the final stage of hypoxia, the beginning of hypoxic damage to cortical cells, infection of the respiratory tract with feces and clinical death.[27]

Based on experimental data and clinical observations, a new functional test was developed to assess fetal resistance to intrauterine hypoxia during the upcoming delivery. This new functional test allows to determine the maximum duration of artificial fetal hypoxia inside the uterus in apnea, as in the Stange test. Only in contrast to the sample, it is not the test object that holds its breath (not the fetus inside the uterus), but its mother, that is, a pregnant woman. In this case, the maximum duration of apnea, which is easily sustained by the fetus, is determined using ultrasound. To do this, ultrasound records the dynamics of fetal motor activity inside the uterus during apnea and determines the duration of the fetal motionless state during respiratory retention in a pregnant woman.

If apnea causes a fetal motionless state that persists during apnea for more than 25 seconds, it can be concluded that the fetus is highly resistant to intrauterine hypoxia and that it is ready to withstand physiological childbirth without hypoxic damage to the cortical cells of the brain. The high value of the sample indicates a very high probability of giving birth to a live and healthy child in the process of urgent physiological delivery.

If apnea causes fetal immobility for less than 10 seconds, it is possible to conclude that the fetus is not resistant to intrauterine hypoxia, and it is possible to predict fetal asphyxia, hypoxic damage to fetal cortical cells, and the development of encephalopathy after physiological delivery, drowning of the fetus in amniotic water, airway blockage with fecal matter, pneumonia, low Apgar score, and clinical death.

In other words, the appearance of the distress call of the fetus earlier than 10 seconds from the start of breath-holding a pregnant woman in the second half of pregnancy can be regarded as a contraindication for physiological childbirth as the high likelihood of neonatal asphyxia, low Apgar and death of the fetus during labor from hypoxia. At the same time, such an early appearance of a distress signal from the fetus during apnea in a pregnant woman may be an indication for the birth of the fetus by Cesarean section, since in this case the fetus may be born alive, healthy and the newborn may have high values on the Apgar scale.[35–40]

Therefore, the proposed functional test has a high prognostic value, since it increases the accuracy of predicting the perinatal outcome of the child's birth process, and can also be the basis for recommending Cesarean delivery.

This functional test can be used in the second half of pregnancy and can be called the "Urakova test on fetus distress signal in apnea".

5. Conclusion

Fetal resistance to intrauterine hypoxia during pregnancy and childbirth plays a very important role for the development of its brain, maintaining health and life. Normally, the fetus has a very high resistance to hypoxia, so it can easily withstand apnea lasting more than 25 seconds and similar contractions of the uterus during physiological childbirth. But sometimes the fetus can have very low resistance to hypoxia, so its brain cells can die from hypoxic damage when a pregnant woman stops breathing and/or when the uterus contracts during childbirth. To save the fetus in this situation, many centuries ago, it was proposed to remove the fetus from the uterus immediately by Cesarean section. However, there is still no standard scale for evaluating fetal resistance to intrauterine hypoxia in order to accurately choose a safe method of birth between physiological delivery and Cesarean section.

However, about 10 years ago, a non-invasive method for sonographic assessment of fetal resistance to intrauterine hypoxia was developed in Russia. This method is based on the definition of the maximum possible period of apnea, proposed more than 100 years ago by the Russian researcher V.A. Shtange and known as the "Shtange test". But unlike the classic Stange test, the innovative method is based on sonographic diagnostics of the "distress signal" given by the fetus inside the uterus of a pregnant woman when the fetus has exhausted all the reserves of adaptation to hypoxia. Thus, the result of the proposed method is determined by the reaction not of the woman, but by the reaction of her fetus.

It was found that with high resistance to hypoxia, the fetus is motionless for more than 25 seconds when a pregnant woman holds her breath. In this case, the fetus can be born alive and healthy as a result of a physiological delivery or Cesarean section.

It was also found that when the fetal resistance to hypoxia is low and/or when all the reserves of adaptation to hypoxia are exhausted, the fetus sends a distress signal in the form of a sudden increase in motor activity less than 10 seconds after the beginning of breath retention by a pregnant woman. In particular, there are respiratory movements of the chest.

This fetal motor activity (distress signal) is well detected by ultrasound. In this case, the fetus can be born alive and healthy only as a result of Cesarean section, and physiological childbirth is contraindicated.

This functional test can be called the "Urakova test on fetus distress signal in apnea".

We believe that the use of Urakova test on fetus distress signal in apnea will help to reduce infant mortality during childbirth, improve the health of newborns, and reduce the cost of obstetric care.

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Nil.

7. Conflicts of Interest

There are no conflicts of interest.

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