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EARLY DIAGNOSTICS OF PREECLAMPSIA RISK USING DOPPLER ULTRASOUND

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Abstract: Pre-eclampsia (PE) remains the leading cause of severe placental disorders, placental insufficiency, and hypoxic lesions of the fetal central nervous system. Early detection of hemodynamic decompensation prevents intrapartum fetal death and disabling neurological outcomes. In this regard, the aim of the study is to investigate the characteristics of fetal cerebral blood flow in pregnancies complicated by pre-eclampsia of varying severity to optimize the management and timing of delivery. Based on a comprehensive analysis of the results of ultrasound and Doppler studies of pregnant women whose pregnancies were complicated by pre-eclampsia, it was established that the progression of pre-eclampsia correlates with a decrease in the pulsatility index (PI) of the middle cerebral artery (MCA) and a critical drop in the cerebroplacental ratio (CPR), reflecting the brain-sparing effect under hypoxic conditions. An algorithm has been developed that allows timely differentiation between the compensated stage of adaptation and critical decompensation. Thus, Doppler assessment of the cerebroplacental complex in pregnant women with PE is a highly accurate method for predicting perinatal outcomes and serves as a key criterion for choosing between prolongation of pregnancy and emergency delivery.

Keywords: pre-eclampsia, dopplerometry, middle cerebral artery, cerebroplacental ratio, fetal hypoxia, obstetrical tactics.

Relevance of the topic. Preeclampsia (PE) remains to this day one of the most complex, multifactorial and prognostically unfavorable complications of the gestational age. It is a global medico-social problem in modern obstetrics and Perinatology. According to modern perceptions, on the basis of the pathogenesis of PE lies the phenomenon of defective placentation, which manifests itself in the first three months of pregnancy. Since the uterine muscle layer of the cytotrophoblast does not completely penetrate the spiral arteries, the transformation of these blood vessels from muscle-elastic vessels with high resistance to wide sinusoidal channels with low resistance does not occur accordingly.

According to the World Health Organization (who) epidemiological reports from 2025-2026, the frequency of occurrence of hypertensive disorders in the world is maintained steadily in the range of 3-8% of the total number of births. PE has claimed tens of thousands of women's lives each year, indirectly causing about 16% of maternal deaths. At the same time, in developing countries and specialized perinatal centers of the third level, these indicators are significantly

higher than the general population indicators. According to multicenter studies in the Republic of Uzbekistan, the frequency of PE varies from 18% to 25% in population, while in institutions with a high risk of obstetrics it reaches 30-35% and occupies the leading positions among the causes of maternal and perinatal morbidity and mortality.

For a developing fetus, preeclampsia in the mother results in fetal growth retardation syndrome (Ox), chronic antenatal hypoxemia, and acidosis formation. A long restriction in the supply of nutrients and oxygen will end the metabolic reserves of the fetus. Against such an unfavorable background, acute decompensation in childbirth leads to severe intranatal asphyxia, deep ischemic-hypoxic damage to the central nervous system (including children's cerebral palsy and gross cognitive impairment in the postnatal period) or antenatal death.

Since the only radical method of treating preeclampsia is still the implementation of timely childbirth (removal of the placenta as a source of antiangiogenic factors), the practitioner always has a critically complex dilemma in front of the obstetrician-gynecologist. On the one hand, a clear balance is necessary between the risk of extreme baldness and yatrogenic respiratory distress-syndrome in early labor, and on the other — the risk of fetal death or the development of severe thalvasa attacks (eclampsia) in the mother.

In this regard, there is a serious need to look for highly sensitive, non-invasive and objective methods for predictive (predictive) control of the functional state of the fetus. The main and most convenient means of modern antenatal Diagnostics is ultrasound dopplerometry. Assessment of blood flow rate curves in the uterine arteries and umbilical artery (ka) makes it possible to characterize the degree of satellite resistance (resistance). However, a separate study of uterine-placenta circulation does not give a complete picture of the compensatory condition in the fetus itself.

Today, the greatest prognostic and diagnostic value is the examination of intracranial (intra — cranial) hemodynamics in an extended way, in particular, the assessment of resistance in the midbrain artery (spinal cord) of the fetus and the subsequent calculation of an integral indicator-the Cerebro-placentar ratio (SPN). The calculation of SPN allows the clinician to notice subtle hemodynamic reconstructions (brain protection effect or brain-sparring effect) in the early stages and to distinguish the adaptive Phase of the fetus from critical compensation disorder in a timely manner, which is decisive for choosing the correct delivery time and method.

The purpose of the study is to increase the accuracy of predicting unfavorable perinatal consequences in patients with preeclampsia and optimize obstetric tactics based on dopplerometric markers of fetal cranial hemodynamics.

Research materials and methods. The study included 150 women whose gestational age corresponded to the II and III trimesters of gestasia and whose pregnancies were accompanied by a background of varying degrees of preeclampsia. All patients were divided into 3 groups: Group 1: 50 healthy pregnant women; Group 2: 60 women with moderate preeclampsia; group 3: 50 women with severe preeclampsia observed.

Criteria for introducing patients: one-fetal pregnancy; presence of an approved PE (arterial pressure ≥140/90 mmHg with proteinuria after the 20th week of gestation); dynamic dopplerometric screening.

All patients were divided into 3 groups: Group 1 (control): 50 women with physiologically occurring pregnancies (to demonstrate normal rates of PI and SPN); group 2 (Primary): 60 women with moderate preeclampsia; group 3 (primary): 50 women with severe preeclampsia.

All pasients were given UTT with fetal fetometry, amniotic fluid volume assessment (amniotic index), and extended dopplerometry on expert-class UTT apparatus. Pulsation index (PI) was studied in the uterine arteries, umbilical artery (ka), and fetal midbrain artery (spinal cord). Based on the indices obtained, the tserebro-placentar ratio was calculated (SPN = O'ma PI / ka PI). The consequences of childbirth, the frequency of operational interventions and the state of newborns at birth were analyzed (Figure 1).

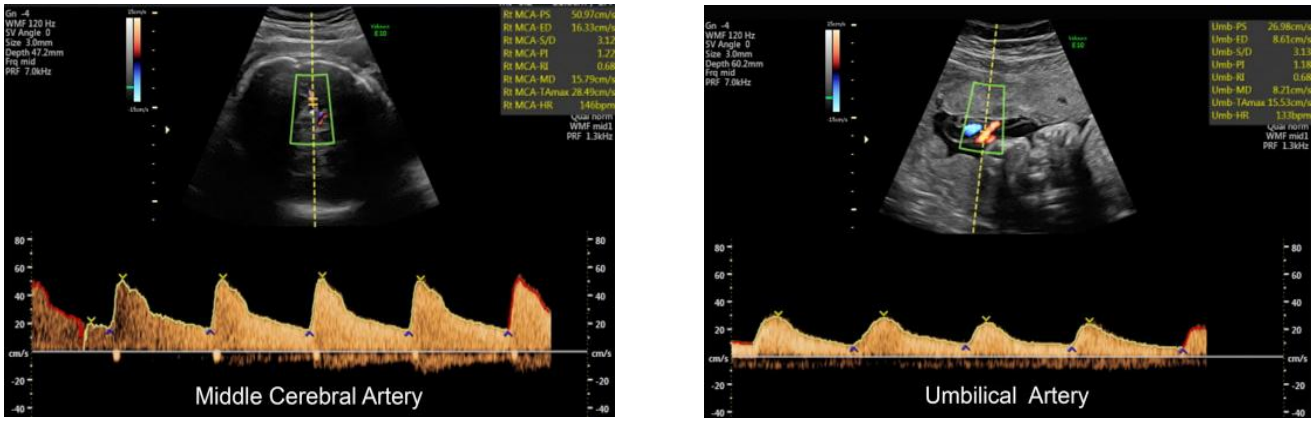


Figure 1. Normal circulation of OVA and KA in ultrasound dopplerography

Research results. When the somatic Anamnesis of patients in the main group (Group 2 and group 3) was analyzed, a high frequency of background pathology was determined. Chronic arterial hypertension present before pregnancy was reported in 28.3% of women with moderate PE and 46.0% of patients with severe PE. Overweight and I-II obesity were observed in 35.0% and 42.0% of cases respectively. The parity structure was dominated by first-born women (58.3% in Group 2 and 64.0% in Group 3 being the first pregnancies). While the average age for the manifestation of clinical signs of preeclampsia was 32.4 ± 2.1 weeks of gestasia in a moderate group, in severe form, the initial signs (pronounced proteinuria, stagnant hypertension) were recorded much earlier — at 28.2 ± 1.8 weeks, requiring premature hospitalization in an intensive care unit.

The results obtained make it possible to accurately distinguish the stages of functional adaptation of the fetal cardiovascular system with an increase in the weight of preeclampsia. In the moderate preeclampsia phase, placentar dysfunction has a compensatory nature. Increased resistance in the umbilical artery does not yet cause generalized surges, while intracranial vessels retain a stable tone (SPN > 1.0). This allows clinicians to follow conservative, waiting tactics with the aim of prolonging pregnancy in order to achieve maximization of the surfactant system of the fetal lung.

The transition of pathology to the stage of severe preeclampsia indicates a violation of compensatory capabilities. The fall of SPN below the critical sign (<1,0) is a direct perception of vasodilation (vascular dilation) of the cerebral esophagus against the background of severe hypoxia. The occurrence of zero or reversive (reverse) diastolic blood flow in Ka indicates that more than 70% of the satellite vascular system has left the circulatory system. In this situation, the extension of pregnancy is associated with a very high risk of antenatal fetal death, which necessitates immediate delivery after a short course of stabilization of the mother's condition.

A decrease in the pulsation index in the midbrain artery is indicative of compensatory vasodilation of the cranial vessels (brain-sparring effect). This mechanism is activated during PE to ensure adequate perfusion of fetal mat under conditions of reduced placental blood flow.

However, the drop in the integral index SPN below 1.0 indicates a critical blood redistribution and the termination of fetal adaptive reserves. A separate narastania of PI in the umbilical artery with SPN preserved allows conservative carrying and hypotensive therapy under ultrasound control. In contrast, the manifestation of pathological (low) SPN along with the severe clinical picture of PE in the mother (oliguria, pronounced proteinuria, neurological signs) serves as an absolute indication for operative childbirth due to the high risk of antenatal death

Statistical analysis has determined a highly reliable ($p < 0.01$ and $p < 0.001$) dynamics of all studied dopplerometric indices as preeclampsia progresses. The combined change in resistance dispenses attention: in the severe PE group, the pulsation index of uterine arteries (PI) more than doubled compared to control (1.68 ± 0.12 against 0.72 ± 0.04), which confirms a deep violation of uterine-placenta perfusion due to a defect of remodeling of spiral vessels. Against the background of this, the umbilical artery PI legally rises to 1.45 ± 0.09.

The most demonstrative criterion for decompensation is the dynamics of OMA indicators. If only a downward trend is observed in a moderate peda OMA Pi (1.42 ± 0.09), in severe form it drops very sharply (0.98 ± 0.07; $p < 0.01$). This indicates the maximum expansion of the fetal cerebral arteries (brain-sparring effect) in order to protect vital centers of the brain.

The Integral indicator SPN showed the highest diagnostic sensitivity ($p < 0.001$). Its value in the heavy PE group dropped to a critical 0.67 ± 0.05. This proves that calculating SPN allows you to identify hidden signs of hypoxic stress much earlier than a separate examination of the umbilical artery or uterine vessels, and makes this indicator the main predictor of unfavorable perinatal consequences (Figure 2).

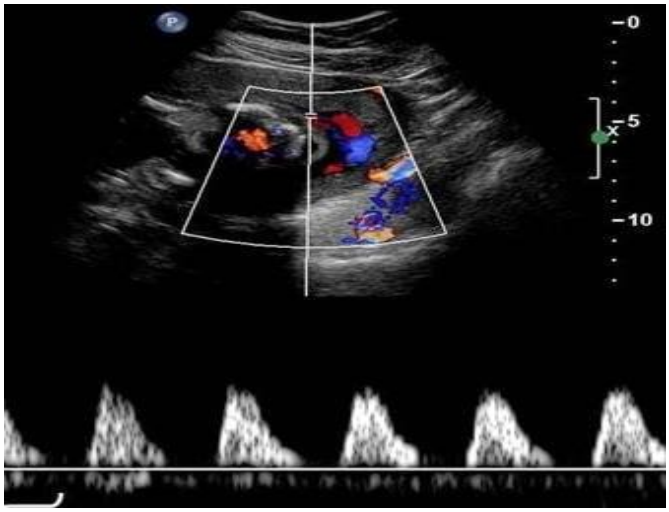


Figure 2. The complete absence of final diastolic blood flow (zero blood flow) in the umbilical artery indicates a critical condition.

Assessment of children's birth status found a direct correlation between antenatal SPN values and assessment on the Apgar scale. In the control group, all children were born with 8-9 points in the 1st and 5th minutes. In the moderate PE group, the grade was 7-8 points.

In a group with severe PE and critical SPN (< 1.0), the average Apgar grade was 4-5 in the 1st minute and 6-7 in the 5th minute, as evidenced by acute or decompensated chronic hypoxia performed. In Group 3, the frequency of operative delivery (caesarean section surgery) was 88.0%, of which in 42.0% of cases the indication was precisely the deterioration of fetal dopplerometric indicators in dynamics. 64.0% of Group 3 infants were transferred to the neonatal resuscitation and intensive care unit (YACHRITB), of which 38.0% were diagnosed with signs of moderate to severe levels of ischemic mat injury.

Conclusions. Complex dopplerometric monitoring of fetal-cerebral blood flow is a high-resolution way to assess the functional state of the fetus in preeclampsia. The development of pathology is accompanied by a decrease in the midbrain Artery Pulsation index (spinal PI) and a critical drop in the tserebro-placentar ratio (SPN < 1.0), which clearly reflects the phenomenon of circulatory centralization (brain-sparing effect) triggered under hypoxia conditions. The use of the integrated indicator SPN makes it possible to distinguish the Compensated stage of adaptation from critical decompensation in a timely manner, and serves as the main diagnostic criterion for optimizing obstetric periods between the extension of pregnancy and the choice of urgent childbirth.

Thus, the use of complex ultrasound dopplerometric monitoring (OVA, ka and SPN) allows you to objectively assess the level of hypoxic stress of the fetus, optimize the duration of childbirth in preeclampsia, and minimize the risk of yatrogenic complications and intranatal losses in women.

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