Violation of the Cardiovascular System and Water Balance in Pregnant Women with Gestosis

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ABSTRACT

Understanding of the degree of dysfunction of organs and systems in pregnancy, associated with gestosis is extremely important for anesthesiologist, because it affects the tactics of the patient, the choice of anesthesia and therapy program. The article reviews the literature on the problem of hemodynamics and water balance in pregnant women with gestosis, anesthetic management of this category of patients.

Keywords: anesthesiology, pregnancy, gestosis, hemodynamics, water balance, spinal anesthesia, monitoring, operation, caesarean section.

Pregnancy is accompanied by changes in the function of many organs and systems of an organism of the woman. This is due to the growth and development of the fetus, increased body mass of women, the emergence of a new placental circulation and many other changes that occur in a woman's body [6,37,49]. Significant changes are characteristic for the cardiovascular system and water balance of an organism of the pregnant woman.

Normally, pregnancy is accompanied by a significant increase in circulating blood volume (CBV), the total volume of water (TVW) of an organism and increase of operation of all system of blood circulation [42,56]. If with physiological pregnancy and childbirth these changes remained within acceptable, with the development of gestosis shifts may reach critical values, clinically manifesting preeclampsia, eclampsia and pulmonary edema. Therefore, objective information about the state of the cardiovascular system and water balance, the degree of their violations is extremely important and relevant for professionals involved in obstetric clinics.

One of the main criteria of successful pregnancy and delivery is stable hemodynamics [6,48]. Hence, pregnancy, requiring that the system of blood circulation increased requirements, should also include mechanisms to ensure these new conditions. The system of blood circulation pregnant there are various compensatory changes, destination which is to ensure the normal development of the fetus and future safe delivery [20,21].

The minute volume of circulatory system (VSC) was increased by 8 weeks of gestation on 1 l/min, It is 22% from its level prior to the pregnancy and 57% of the total increase of the VSC reaches its maximum at 24 weeks pregnant [9,12,44].

As a result of Korotkova M.E. research it was found that in physiological pregnancy values stroke volume circulation (VSVS) range from 82,4± of 20.8 ml within 10-12 weeks to 96.6±16,1 ml at term of 38 weeks. The VSV in the same period varies from 5.8 about 1.6 l/min up to 7.35±1.25 l/min [22].

On 8-10 weeks of gestation, cardiac output increases by 30-40%, mainly due to the increase of stroke volume and to a lesser extent, by increased heart rate [2]. The peak load on the circulatory system accounted for 28-29-th week of pregnancy. The cardiac output increases and blood pressure remains the same and/or declining. Total peripheral vascular resistance (TPVR) decreases, and to the 14-24th weeks of pregnancy is reduced to 979-987 dyn cm sec^{-5}.

In the work Stepanyan A.V. [et al.] it was established that the reorganization of the system of blood circulation to the end of the term of pregnancy is to increase the VSV on average by 21% and the work of the heart by 35%, increasing TVO 11% and extracellular fluid (Extracell) at 19, against the background of reduced TPVR on 24% [44].

This stress on the heart does not go unnoticed and causes its morphological changes. So, according to the U.S. studies have found that during pregnancy occurs thickening posterior walls of the left ventricular myocardium and slightly increasing its mass index [31, 39].

Of course, the severity of the changes of hemodynamics during pregnancy depends on the presence of concomitant pathology of the cardiovascular system. So, increase in blood pressure with concomitant arterial hypertension caused by increase of cardiac output at the average rate of 15% (women without obesity 20% and obesity by 9%) and the work of the heart by 31%, compared to healthy women, on the background of practically constant TPVR digits.

According to the WHO, from 20 to 33% [24, 27, 28, 35] cases of maternal mortality are connected with arterial hypertension (AH). Frequency of hypertensive states in pregnant women ranges from 17% to 24% [40], and in specialized hospitals of high risk, it reaches 28-30% [21,25,36,38]. In different regions of Russia it is from 7 to 29% [27].

One of the most frequent complications of pregnancy and complex sections midwifery practice is preeclampsia, which is marked with disorders of the cardiovascular system and water balance [42]. Preeclampsia occupies one of leading positions in the structure of maternal mortality causes [23,29,30,49,55]. In the general population of pregnant women the frequency of adverse options for the development of gestosis - preeclampsia and eclampsia is respectively 5-10%, and 0.05%, there is no tendency to reduction [46,47,50,51]. In Russia the rate of maternal mortality, associated with preeclampsia and eclampsia, reaches 20% and ranks second place after bleeding [42].

Beginning of development of gestational hypertension is characterized by an initial decrease in MV average on 42% and the work of the heart on 32% and increase in TPVR by 101%, with invariable liquid volumes. The main distinctive feature of the pathogenesis of gestational hypertension in pregnant women with obesity is to increase the TVB by 22% and increased Extracell 27%, in contrast to pregnant women with gestational hypertension without obesity [44].

K. Melchiorre and G. R. Sutherland when conducting echocardiographic study of pregnant women with preeclampsia have revealed that the majority of women tend to have diastolic dysfunction of the heart, which is a sign of progression of the disease [5].

For the most precise specifications of the pregnant hemodynamics A.P. Zilber and E.M. Shifman distinguish three variants: hyperkinetic type is characterized by cardiac index (CI), more than 4.2 l/min/m^2 and TPVR less than 2500 cm^{-5} x s^{-1}; eukinetic type - CI 2,5-4,2 l/min/m^2 and TPVR within 1500-2000 cm-5 x s^{-1}; hypokinetic type - reduction SI to 2.0 l/min/m^2 or less, and the TPVR rising up to 5000 dyn cm^{-5} x s^{-1} [49].

Even at normal pregnancy due to a mismatch of BCC and capacity of the vascular bed volemic disorders occur [11]. During pregnancy, there are significant changes in the quantitative composition and qualitative of intracellular fluid and inner cellular fluid. Average fluid growth during pregnancy is 6 to 9 l, 4 – 6 liters from which fall on the extracellular sector.

VCB progressively increases, ranging from 6-8 weeks of pregnancy, and reaches a maximum of approximately 30 weeks [22]. The components of VCB grow unevenly: the volume of the circulating plasma was increased by 40-50%, while the volume of formed elements of blood only 20-30%. Therefore hematocrit reduced (to 32-34%) and hemoglobin concentration that allows to consider pregnancy as one of the types olygocitiemia [52,11].

Analysis of all the changes of the water balance suggests that pregnancy contributes to increase the filtration of a fluid in the interstitium and increases vessel out fluid. The most dangerous consequence of all violations is interstitial pulmonary hyperhydratation, which could lead to the development of pulmonary edema [6,8,16,32].

Swelling is one of the triad of symptoms of preeclampsia, are only the outward manifestation of violation of the liquid distribution between extracellular and intracellular sectors. In severe forms of pre-eclampsia, dyshydria and tissue hypoxia are saved and in the

postpartum period [1,33,48].Found that in puerperas in eclampsaia coma there is a pronounced hyperhydratation, with isotonic character [32,34]. The total volume of liquid Grozny deterioration in average 31,26% above the normal value that is associated with increased Extracell on 173,6% in comparison with the norm. These impacts are hyperhydratation in interstitial sector, the volume of which exceeded the norm on 97,4%. VCV is reduced, and a deficiency due to a decrease in plasma volume. These values are much below those that take place during normal pregnancy [16,32,34].

However, stable hemodynamics does not guarantee that the perfusion of organs and tissues will be maintained at the proper level. At infringement of water balance of the body tries to compensate the lack of perfusion through redistribution of blood flow to vital organs. When this occurs, the activation of the sympathetic part of vegetative nervous system and the renin-angiotensis system, which leads to the development of a vicious circle, which helps to keep hypoperfusion [6,10,34].The emergence of alternative, non invasive methods of assessment of Central hemodynamics and water balance, allowed to expand their clinical application.

T. Sodolski and A. Kutarski in their work showed that application of the method of integral reography pregnant for monitoring of Central hemodynamics completely exclude the possibility of complications, which occur when using invasive methods [13]. Basic methods that allow for a quick update extent and nature of the shifts of the cardio-vascular system disorders water balance are the methods based on the principles of reographyaimpedansometria [8].

Delivery requires the organism of a pregnant maximum voltage of all organs and systems, because it is the most traumatic moment during the whole period of gestation. Operation Caesarian section for the mother and the foetus is the most complicated and stressful variant of delivery, as anesthesia, surgery, drug exposure may lead to undesirable consequences. In this serious situation dependence obstetric outcome of the quality and effectiveness of anesthesiological protection of the mother and the fetus is not in doubt [2,17,18,19,26].

Of course, in a state of eclampsia and other life-threatening conditions such as obstetric hemorrhages, development hypocoagulation, septic complications absolute indication is the use of General anesthesia, usually combined endotracheal narcosis is the method of choice at the listed above clinical situations. However, when applying this method of anesthesia it is necessary to consider the metabolism of drugs (hypnotics, anesthetics, narcotic analgesics and muscle), and their effect on the organism of the woman and the fetus, as well as the impact on hemodynamics.

Most of these groups of drugs used during anaesthesia have direct or indirect impact on the system hemodynamics. So, widely used hypnoticand barbiturat - sodium thiopental causes a reduction in blood pressure, cardiac output, TPVR by depressive action on the cardiovascular center and subcortical structures. However, according to E.K. Aylamazian, thiopental sodium at a dose of 4-5 mg/kg is the drug of choice in stopping eclamptic cramps [3].

Only in anesthesiology drug that increases blood pressure, and cardiac output by stimulation of the cardio-vascular centre and activate the limbic structures – ketamine can be used in any hypotonic conditions in obstetrics and expressed cardio-vascular insufficiency.

In spite of research, denying the depressive effects of fentanyl on the fetus, it is still an open question about the use of narcotic analgesics till the moment of extraction of fetus [4,22, 57].

Central analgesic - Remifentanil provides the best cardiovascular stability in tracheal intubations. The systematic study of Remifentanil with as a component of general anesthesia for cesarean section it is shown that the induction dose of 0.5 mg/kg followed infusion in the range of 0.2 mg/kg/min with propofol effectively modulate stress response and provides hemodynamic stability in women in labour [50]. Depression of newborn respiration was only in a few cases and was resolved within two minutes using mask ventilation. Advantages of Remifentanil in comparison with other opioids in clinical practice are primarily in ultra short elimination and its

depending on the individual patient's needs. The half-life of the drug (the time needed to reduce the concentration of the drug in the blood to 50%) following termination of infusion is 3 minutes.

The study of A.A. Shmatova revealed that inhalation low flow anesthesia based on sevoran in comparison with the total intravenous anesthesia with artificial ventilation of the lungs during a cesarean section provides stable parameters of blood circulation in pregnant women [52].

E.N. Sivkov [43] works on optimization of anesthesia with operative delivery revealed that hemodynamic changes in the process of operations depend on the methodology of anesthetic management. In low-inhalation anesthesia sevoran place has a moderate decrease by 12.7 - 20, 5% from baseline) blood pressure with a maximum of 5 minutes after removing the fetus and the stabilization of the number of heart contractions. However, the amount of the average CD couldn't fall less than 70. On the contrary, total intravenous anesthesia is accompanied by the increase of blood pressure (8.5 - 8.7 % of the initial level), heart rate (12.8 15.2 per cent from baseline) and consumption myocardial oxygen (21.4 % of the baseline) in the period surgery and anesthesia. Their return to the initial value occurs only in the early postoperative period [41].

Recently the anesthetic gas xenon (Xe) in clinical anesthesiology is actively introduced. Xenon acts as an alternative to nitrous oxide in the combined endotracheal anaesthesia**.** Xenon, being the noble inert gas, easily penetrates through the lungs, well soluble in fats (solubility coefficient of oil-water equal to 20), not biotransformation and after the termination of gas supply for 5 minutes out from the body. Xenon does not have toxic effect on the organism of the mother and fetus, does not cause cardiodepression effect, has no effect on the morphology and tromboelastographic blood, does not change neuroendocrins status, provides reliable anesthesia protection. Despite the advantages of narcosis should remember about the serious problem of clinical anesthesiology - the problem of difficult intubation of the trachea, the most acute exactly in obstetric practice [52]. The main factor in the difficulties intubation during pregnancy areoropharyngeal edema of the mucous membrane and upper respiratory tract. So expect that when pregnancy with preeclampsia risk if intubation is increased in several times.

Some difficulties arise with the adequate ventilation of the lungs, caused by the reduction of gas exchange area of lung due to a reduction in vital capacity due to the increase in intra-abdominal pressure and swelling of lung tissue. Therefore, the parameters of artificial lung ventilation has its own peculiarities. First, the parameters of pulmonary ventilation should take into account the above changes lead to a reduction of diffusion-perfusion relationships. In addition, in pregnant women with preeclampsia very often develops pulmonary hypertension. Therefore, I recommend the following parameters of artificial ventilation of lungs respiratory minute volume 7-8 l/min respiratory rate not less than 18 at the moment and it is permissible to use a positive pressure on the exhale to 5 mm.hg. When using inhaled anesthetics proportions of gases should be 1:1 [52].In recent years in obstetrics popularity receive methods of regional anesthesia: spinal, epidural and combined CSE for labour epidural anesthesia. In obstetric clinics of Europe and North America share of regional anesthesia reaches 80-85% [52,53,54]. The popularity of regional methods of anesthesia is due to their relative simplicity, availability and economic viability. In clinical practice has accumulated a great experience, demonstrating the high efficiency of regional anesthesia, its ability to reliably blockpain sensitivity, to prevent the neuro-vegetative reaction, provide good relax of muscles. Moreover, the trend in recent years - the displacement of General anesthesia regional methods [53].

Other positive aspects of neuroaxial methods are adequate analgesia, quick start (in 3-5 minutes after spinal anesthesia, 15-20 min after epidural anesthesia), lack of systemic toxicity [51,52,53].

Research on hemodynamics studying in the intraoperative period in women with physiological pregnancy during spinal anesthesia discovered that the most dangerous period of anesthesia is the time after a dose of local anesthetic because it is associated with a decrease in

sympathetic tonus of vessels [14]. Herewith on the average TPVR was 845±61,7 cm^{-5}, compensatory tachycardia on the average remains within 100 beats/min. In the end of the surgical intervention TPVR= 1072 cm^{-5}. As a result of the research the authors of this work recommend the infusion therapy and the use of atropine for the prevention of decrease in average blood pressure.

In general, hemodynamics depends on many anesthesia factors: the anesthesia method, its technique, position of the patient, of the foetus, the application of vasoactive substances, including oxytocin [54]. In turn, the type of hemodynamics also affects the course of anesthesia. This is evidenced by the data of Tolmachev G.N. et al. [46] for the improvement of anesthetic management in abdominal delivery in pregnant women with hypertension. In the end, it was determined that anesthesia in pregnant women in both groups initially with eukinetics type of hemodynamics was homogeneous, but TPVR in the comparison group was slightly higher. The next important element of anesthesia is infusion therapy in the perioperative period [10].

Currently in clinical practice for the restoration VCV and reduce the interstitial fluid overload widespread preparations based on hydrooxydcrachmal starch [7,40,45].

According to E.N. Kакul et al. [17] in the research for the study of the quantity and quality of infusion therapy during the caesarean section, the following results - the use of balanced and unbalanced solutions in infusion therapy has the same positive effect on the system hemodynamics- were obtained. Thus, the use of balanced solutions unlike unbalanced induces no changes in acid-base status of venous blood. In the work of K.A. Piystunovich [35] a positive impact of Stabisol and Refortan on hemodynamics and hemostasis was revealed, Refortan's rheological effect was shown; there was no negative impact on the contractile function of the uterus and biochemical parameters. According to the author, these drugs can be recommended for use in intensive care at a cesarean section. The same result was obtained in Y.A. Bragin studies [8], who states that the traditional infusion therapy does not allow to fully correct the deficit of the VCV at severe preeclampsia. Inclusion in the program of intensive treatment of preeclampsia Refortan 6%, 10%, Stabisol 6% solutions contributes to the rapid elimination of the deficit of the VCV, a gradual decrease and counter stabilization of systemic blood pressure and TPVR.

Preparations based on hydrooxicrachmal starch, and having the system inflammatory effects, permit their use in treatment of preeclampsia before and after delivery. One of the new drugs on the basis of hydrooxicrachmal is Tetraspan [15].

There are reports of inclusion in the infusion therapy of parturient women with preeclampsia and metabolic acidosis hydrooxicrachmal starch and Reamberin with the purpose of correction of water-sectoral shifts, improve the delivery and consumption of oxygen, normalization of metabolism [11]. Thus, in pregnant women with preeclampsia there are significant changes of the circulatory system and water balance, which requires an absolute exception of errors in tactics, application of the optimal method of anesthesia and adequate fluid therapy. Recognizing the fact that the main criterion of adequacy of anesthesia is stable hemodynamics, a mandatory condition becomes hemodynamic monitoring. This should not only rely on blood pressure metrics, heart rate, and central venous pressure, and also fullly use modern methods of estimation of the central and peripheral hemodynamics, as well as water-sectoral balance. Objective information about the condition of hemodynamics and water balance, their correct interpretation will increase the level of understanding of the ongoing processes in the pregnant woman organism and enable the doctor anesthesiologist to properly manage and maintain well-grounded correction.

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